FINAL

BASELINE HUMAN HEALTH RISK ASSESSMENT
EUREKA MILLS - EUREKA, UTAH

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Prepared for:

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LIST OF ABBREVIATIONS AND ACRONYMS

ATSDR   Agency for Toxic Substances and Disease Registry
BOR   Bureau of Reclamation
CDC   Centers for Disease Control
COPC   Chemical of Potential Concern
CTE   Central Tendency Exposure
CUPHD   Central Utah Public Health Department
DERR   Division of Environmental Response and Remediation
DI   Daily Intake
DL   Detection Limit
EDF   Empirical Continuous Distribution Function
EPC   Exposure Point Concentration
GM   Geometric Mean
GSD   Geometric Standard Deviation
HI   Hazard Index
HIF   Human Intake Factor
HQ   Hazard Quotient
ICP   Inductively Coupled Plasma
IEUBK   Integrated Exposure, Uptake, and Biokinetic Model
IRsd   Soil and Dust Ingestion Rate
ISE   Integrated Stochastic Exposure Model
P10   Probability of a Blood Lead Value over 10: g/dL
PbB   Blood Lead
PDF   Probability Density Function
PRA   Probabilistic Risk Assessment
RBA   Relative Bioavailability
RBC   Risk Based Concentration
RfD   Reference Dose
RME   Reasonable Maximum Exposure
SF   Slope Factor
USEPA   US Environmental Protection Agency
UCL   Upper Confidence Limit
UDEQ   Utah Department of Environmental Quality
XRF   X-ray Fluorescence

EXECUTIVE SUMMARY

Site Description and Background

The town of Eureka, Utah, is located in the East Tintic Mountains approximately 70 miles southwest of Salt Lake City and 40 miles southwest of Provo (Figure ES-1). The Tintic district is the second-most productive base- and precious-metal mining district in Utah (Morris and Mogensen 1978).   In July 2000, the Utah Department of Environmental Quality Division of Evironmental Response and Remediation (UDEQ/DERR) observed elevated concentrations of lead (ranging up to 47,800 ppm) in site soils. Because these values are well above the U.S. Environmental Protection Agency's (USEPA's) default level of concern for residents (400 ppm), and because these elevations occur in close proximity to residents of Eureka, it was determined that a threat to human health and the environment was present at this site. As a result, EPA began a Removal Evaluation at this site on August 28, 2000.

The purpose of this document is to utilize data collected during this Removal Evaluation to characterize the nature and magnitude of risks which mining-related wastes pose to humans who may be exposed in the vicinity of the site.

Data Summary

Soil Data

Two data sets were obtained for soils from this site. Data set #1 contains analytical results for soil samples (N= 4,211) collected from residential properties. Data set #2 contains results for soils (N=265) collected from background locations and non-residential (primarily mine-waste) areas surrounding Eureka. All of these soil samples were analyzed via X-ray Fluorescence (XRF) and approximately 10% of these samples were also analyzed via Inductively Coupled Plasma (ICP) methods. Each data set underwent a data quality evaluation consisting of a two-step process to determine if the data were adequate for use in this risk assessment.

Numerous data issues were identified with the XRF data sets. Several chemicals were found to have inadequate XRF detection limits, and others did not correlate with results obtained using ICP. Therefore, only data sets deemed reliable for use in the risk assessment were used. Summary statistics for the data sets deemed reliable are shown in Tables ES-1 and ES-2.

Dust Data

Indoor dust samples were obtained from a total of 57 residences within the study area and analyzed via ICP for 23 metals. No data quality issues were identified with this data set. Summary statistics are provided in Table ES-3.

Basement Soil Data

Composite soil samples (0-2") were collected from 7 homes which were observed to have earthen basements. Summary statistics for metals (analyzed via ICP) are presented in Table ES-4. No data quality issues were identified with this data set.

Paint Data

Analysis of lead levels in paint was conducted at 23 homes within Eureka. Table ES-5 provides summary statistics for both interior and exterior paint measurements stratified by observed condition. Overall, the mean detected value in all interior samples was 0.20 mg/cm^2, with a range of 0.01 to 1.7 mg/cm^2. For exterior samples, the mean was 0.44 mg/cm^2, with a range of 0.01 to 1.4 mg/cm^2.

Tap Water

First draw tap water samples were collected from a total of 54 households and were analyzed via ICP for 23 metals. Summary statistics are provided in Table ES-6. Due to concerns over thallium, additional tap water samples were collected and analyzed using a lower specified detection limit. Based on this analysis, thallium was not detected in any sample at a detection limit of 1 ug/L.

Physical-Chemical Characterization of Site Soils

A set of 17 site soils collect from the Eureka area (Figure ES-2) were submitted for physical-chemical characterization. This characterization consisted of speciation analysis, evaluation of size distributions, and *in vitro* testing for bioaccessability.

Arsenic in site samples was found to occur mainly in the iron oxide and lead-arsenic oxide phases, with a smaller fraction present in iron sulfate. The majority of all arsenic-bearing particles are <100 um in diameter. Lead occurs primarily as cerussite. In most samples, the majority of lead-bearing particles are 5-100 um in diameter. Bioaccessability for arsenic in these samples ranged from 4 to 42%. The bioaccessability for lead in these samples was observed to range from 60 to 89%.

Selection of Chemicals of Potential Concern

The Chemical of Potential Concern (COPC) selection process for soils was based on data sets meeting the requirements of the data quality assessment. The full tap water data set collected at this site was utilized to screen for COPC's for this media. Using these data sets, COPCs were selected using a four step selection process as follows:

> ***Step 1: Evaluation of Essential Nutrients***
> ***Step 2: Evaluation of Detection Frequencies***
> ***Step 3: Comparison with Background Concentrations*** (soils only)
> ***Step 4: Toxicity/Concentration Screen***

Based on these steps, the following COPCs for soil and water were selected for quantitative evaluation in the risk assessment at this site.

Chemical	Soil COPC	Tap Water COPC
Antimony	X	
Arsenic	X	X
Cadmium	X	X
Iron	X	
Lead	X	X
Manganese	X	
Mercury	X	
Silver	X	
Thallium	X	

Exposure Assessment

There are a number of different groups or populations of humans who may come into contact with contaminants in site media, including current residents, future residents, and recreational visitors. The following exposure scenarios were judged to be of sufficient potential concern to warrant quantitative exposure and risk analysis at this site:

Exposure Scenarios of Potential Concern

Location	Population	Medium and Exposure Route
Residential Areas within Eureka	Current Residents	Incidental ingestion of soil and dust Ingestion of tap water
Non-Residential Areas	Hypothetical Future Residents	Incidental ingestion of soil and dust Ingestion of tap water
	Recreational Visitors	Incidental ingestion of soil and dust

Quantification of Exposure and Risk from Non-Lead Contaminants

Methods

Risks to residents (current and future) and recreational visitors from exposure to non-lead COPCs in site media were evaluated according to standard USEPA methods.

All exposure and toxicity factors used for the varying exposure scenarios are presented in Chapter 4 of the risk assessment. The relative bioavailability of arsenic was estimated based on arsenic absorption studies in animals for samples from other sites, using information on the geochemical characteristics of arsenic bearing particles in site soils to identify which results are most similar. The value selected was 55%, which is somewhat lower than the default value of 80%. All other non-lead COPCs were evaluated using an RBA of 1.0.

Exposure Areas

The residential area of Eureka was divided into six exposure areas of approximately equal size (Figure ES-3). Selection of the exact locations of the boundaries for each area was largely judgmental, and was based mainly on the pattern of concentration values and convenient natural boundaries such as current city

streets. Risks from exposure to soil and dust were evaluated within these six areas as well as across the site as a whole. Because the city of Eureka is supplied by a municipal water system, no exposure areas were designated for this media.

The non-residential areas were divided into 7 exposure areas based primarily on geographic location in order to represent potential exposure areas for recreational activities.

Concentrations of Non-Lead COPCs

Because the true mean concentration of a chemical within an Exposure Point cannot be calculated with certainty from a limited set of measurements, the USEPA recommends that the upper 95th confidence limit (UCL) of the arithmetic mean concentration be used as the Exposure Point Concentration (EPC) in calculating exposure and risk (USEPA 1992a). If the calculated UCL is higher than the highest measured value, then the maximum value is used as the EPC instead of the UCL (USEPA 1992a). In accord with this policy, EPCs were calculated for each of the COPCs and exposure areas identified at this site. These values are summarized in Tables ES-7 to ES-10.

Noncancer and Cancer Risks

Noncancer risks are described in terms of the ratio of the dose at the site divided by a dose that is believed to be safe. This ratio is referred to as the Hazard Quotient (HQ). If the HQ is equal to or less than a value of 1, it is believed that there is no appreciable risk that noncancer health effects will occur. If an HQ exceeds 1, there is some possibility that noncancer effects may occur, although an HQ above 1 does not indicate an effect will definitely occur. However, the larger the HQ value, the more likely it is that an adverse health effect may occur.

Arsenic was the only COPC at this site listed by EPA as an oral carcinogen. Risk of cancer from exposure to arsenic is described in terms of the probability that an exposed individual will develop cancer because of that exposure by age 70. The level of cancer risk that is of concern is a matter of individual, community and regulatory judgement. However, the USEPA typically considers risks below 1 in a million to be so small as to be negligible, and risks above 100 per million to be sufficiently large that some sort of action or intervention is usually needed.

Results

Risks to Current Residents

As shown Table ES-11, summed risks for Reasonable Maximum Exposure (RME) scenarios exceed an HI value of 1.0 in areas 1, 2, 3, 4 and 5, with the majority of the risk attributable to arsenic and thallium. However, contributions from each individual chemical did not exceed an HQ of 1.0. Across the site as a whole (all areas) RME values exceed the 1.0 level of concern, but

average exposures are below this level of concern. With respect to excess cancer risk to residents, exposure to arsenic resulted in exceedances of a one hundred per million level of concern in exposure areas 3, 4, and 5 (range 101 to 111 per million) under RME exposure scenarios.

Table ES-12 shows risk estimates based on residential consumption of tap water. As seen, summed risks do not exceed a value of 1E+00 under either CTE or RME exposure assumptions. Excess cancer risk does not exceed a value of 1E-04, even under RME exposure assumptions.

Risks to Recreational Visitors and Hypothetical Future Residents

Table ES-13 present risks for exposure (recreational and future residential) at current non-residential areas. For recreational visitors, summed risks exceed a value of 1.0 at all evaluated exposure areas under both average and RME exposure assumptions. As shown in Table ES-13, this elevated risk is primarily attributable to arsenic. However, at some locations, risks from antimony, mercury, and thallium were also elevated. Excess cancer risks were not found to exceed 100 cases per million for average recreational users at any of the non-residential exposure areas. However, under RME exposure assumptions, excess risks were elevated at all locations (range = 349 to 719 per million).

For potential future residents, chemicals in all of the evaluated exposure areas have summed non-cancer and cancer risks exceeding a level of concern under both average and RME exposure scenarios. Risks in the majority of these areas are attributable to arsenic, however in some instances, risks from antimony and thallium also exceed an HQ of 1.0.

Uncertainties

Several assumptions used in the evaluation of risks from non-lead COPCs at this site may introduce uncertainty into the presented findings. Although in most cases, assumptions employed in the risk assessment process to deal with uncertainties are intentionally conservative; that is, they are more likely to lead to an overestimate rather than an underestimate of risk, it is nevertheless important for risk managers and the public to take these uncertainties into account when interpreting the risk conclusions derived for this site.

Uncertainties presented in the risk assessment include: uncertainty in concentration estimates, uncertainty in human intakes, uncertainty in toxicity values, uncertainty in absorption from soil and uncertainty from pathways not evaluated.

Quantification of Exposure and Risk from Lead

Methods

Risks from lead are usually evaluated by estimation of the blood lead levels in exposed individuals and comparison of those blood lead values to an appropriate health-based guideline. In the case of residential exposure, the population of chief concern is young children (age 0-84 months). The USEPA and CDC have set as a goal that there should be no more than a 5% chance that a child should have a blood lead value over 10 ug/dL. For convenience, the probability of exceeding a blood lead value of 10 ug/dL is referred to as P10.

Blood lead levels in an exposed population of children may either be measured directly, or may be calculated using a mathematical model. Each of these approaches has strengths and weaknesses, so both of these approaches were employed at this site, as described below.

Modeling of Lead Risk

Current and Future Residents

The USEPA has developed an integrated exposure, uptake and biokinetic (IEUBK) model to assess the risks of lead exposure in residential children. This model requires as input point estimates of the average concentration of lead in various environmental media in residential properties at the site, and the average amount of these media contacted by a child living at the site. These data are used to estimate the average blood lead value in an exposed child. Then, a distribution of blood lead values is estimated by assuming a lognormal distribution and applying an estimated geometric standard deviation (GSD).

This model was used to evaluate the distribution of blood lead values that would be expected in a population of children living at a specific location, in order to judge whether the risks to any random child living at that location are within health based goals. The model was run for each residence within Eureka (N=505) and for each non-residential property (N=25) for which environmental data were collected.

All of the exposure parameters used as inputs to the IEUBK model were either site-specific concentration values (soil, dust, water) or were the standard EPA-recommended default values, except as follows:

·   The concentration of lead in the diet was adjusted downwards by 30%, based on recent dietary survey data

·   The relative bioavailability of lead in soil was assumed to be 70%. This value was selected by comparing the geochemical characteristics of lead in Eureka soils to a series of soil samples from other sites for which relative bioavailability had been measured in animals.

The resulting predictions of the IEUBK model for current residential children, stratified by exposure area, are shown in Table ES-14.   As seen, geometric mean blood lead values for residential properties are predicted to range from 5.1 to 47 ug/dL, with relatively little difference observed across exposure areas. Based on a GSD of 1.6 (default), PbB_{95} values (95th Percentile Blood Lead) (middle panel) are predicted to range from 11 to 101 ug/dL, with a community wide average of 33 ug/dL. Based on this, 100% of all properties are above EPA's health-based goal (P10 < 5%), and the predicted incidence of children with blood lead levels greater than 10 ug/dL is 69%. Even if a lower GSD (1.4) is assumed, the risks of elevated blood lead levels still exceed EPA's target at most properties, with a predicted incidence of 99%. These results indicate that current risks to children from lead is likely to be well above EPA's health-based goal in nearly all locations at this site.

The resulting predictions of the IEUBK model for hypothetical future residential children are presented in Table ES-15. As shown, the average predicted geometric mean blood lead concentration across all properties was 33.4 ug/dL (range 6 - 81.5 ug/dL). Regardless of the GSD used (1.4 or 1.6), all properties (100%) were found to have P10 values exceeding 5%, including those properties targeted for potential future development (Properties 6 & 25). Using a GSD of 1.6, these P10 values ranged from 16% to 100% (average 91%), whereas with a GSD of 1.4 a range of 8% to 100% (average 92%) was observed.

Recreational Visitors

The risk to teenage recreational visitors from exposure to lead in site media was evaluated using the Bower's model. This model predicts the blood lead level in an adult exposed to lead by summing the "baseline" blood lead level (PbB_0) (that which would occur in the absence of any above-average site-related exposures) with the increment in blood lead that is expected as a result of increased exposure due to contact with a lead-contaminated site medium. This model was run in accord with guidance developed by EPA's Technical Workgroup for Lead (USEPA, 1996).

The predicted geometric mean blood leads and PbB_{95}'s for recreational visitors exposed at different locations are summarized in Table ES-16. As seen, predicted geometric mean blood lead concentrations range from 2.8 to 98 ug/dL (average 24 ug/dL) and PbB_{95} values range from 7 to 259 ug/dL (average 64 ug/dL). The USEPA has not yet issued formal guidance on the blood lead level that is considered appropriate for protecting the health of pregnant women or other adults. Therefore, these results can be interpreted using a health criterion that there should be no more than a 5% chance that the blood level of a fetus will be above 10 ug/dL. This is equivalent to a blood lead concentration of 11.1 ug/dL in the pregnant adult. A comparison of the 95th percentile blood lead levels predicted for site visitors shows that recreational use at 22 of the 24 properties which were

evaluated may result in blood lead levels which exceed a target concentration of 11.1 ug/dL. This shows that the majority of these areas could pose a risk of elevated blood lead levels to teenage recreational visitors.

Measured Blood Lead Values

During the year 2000, a total of 227 Eureka residents participated in a blood lead monitoring study. Table ES-17 presents blood lead summary statistics for the study participants, stratified by age. As seen observed blood lead concentrations ranged from 0.9 to 42.4 ug/dL with a geometric mean of 4.4 ug/dL. Of these participants, thirty-five (~15%) were found to have elevated blood lead levels (> 10 ug/dL). A comparison of site blood concentrations to nationwide statistics shows that geometric mean blood lead levels in children (0 - 19 years) in Eureka (3.1 to 9.1 ug/dL) are higher than the corresponding national geometric mean blood lead values (1.6 to 4.1 ug/dL) for this age bracket.

A total of 174 individuals who participated in this biomonitoring study consented to the release of their blood lead data to investigate the relationship between measured blood lead levels and environmental factors. As a result, data sets were available for 59 children ranging in age from 0-84 months Of these children, 20 (34%) were observed to have blood lead levels exceeding a concentration of 10 ug/dL. No clear trend was observed at this site between blood lead and environmental lead concentrations in residential soils, dust or paint. This suggests that at this site, soil lead concentrations alone are not the principle determinant of blood lead concentrations.

A review of demographic surveys for each participating child (47 respondents) found a significant difference (P<0.05) in blood lead levels of respondents for 7 survey question parameters: family member participating in lead battery work or ceramic painting activities, household tobacco use, and symptoms of weight loss, constipation and trouble sleeping in children. However, for all parameters except household tobacco use, this finding is based on a relatively small sample size (N= 2 to 4) for positive respondents.   In contrast, the difference observed based on household tobacco use had a larger comparison population (N = 12), suggesting that exposure to tobacco smoke in the home may be an important influence on child blood lead levels.

Weight of Evidence

Evaluation of lead risks can be performed using either a modeling approach or direct observations. Because both of these approaches have advantages and limitations, it is important to compare and contrast the results of each approach.

In order to evaluate the agreement between the IEUBK results and the observed blood lead values, the IEUBK model was used to calculate a predicted blood lead value for each participating child (with known environmental concentrations) less than 72 months of age (N=59). Results are shown

in Figure ES-4 and summarized in Table ES-18. As seen in this figure, the model does not accurately predict values similar to those observed in children from this site. Predicted values did not consistently over-or underestimate the observed values for this site, rather the pattern appears to be highly variable. An evaluation of model residuals found that the IEUBK model was tending to systematically overestimate the contribution of soil and dust lead to a child's blood lead level.

As shown in the summary table, 20 out of 59 children (34%) were observed to have elevated blood leads based on biomonitoring, whereas using a GSD of 1.4 or 1.6, the IEUBK model predicts that 50.3% and 50.6% of this subset of children will have elevated blood leads, respectively. Therefore, both the measured and modeled results suggest that elevated blood leads are of concern at this site.

Uncertainties

Several assumptions used in the evaluation of lead risks at this site may introduce uncertainty into the presented findings. Although in most cases, assumptions employed in the risk assessment process to deal with uncertainties are intentionally conservative; that is, they are more likely to lead to an overestimate rather than an underestimate of risk, it is nevertheless important for risk managers and the public to take these uncertainties into account when interpreting the risk conclusions derived for this site.

Uncertainties presented in the risk assessment include: uncertainty in lead concentrations estimates, uncertainty in lead absorption from soil, and uncertainty in the modeling approach. In order to assess uncertainty in the modeling approach, the risk assessment employed a model, referred to as the ISE Model for Lead, which uses probability distribution functions rather than point estimates as inputs for a number of exposure parameters in order to predict a distribution of blood lead concentrations in a given population. The results of a risk evaluation based on the ISE model compared to the predictions of the IEUBK model are presented below:

Model	# of properties	P10 Value (%)				Total with P10>5
		< 5%	5-10%	10-20%	> 20%	
IEUBK Model (GSD = 1.6)	505	0	5	19	481	505 (100%)
ISE Model	505	189	55	57	204	316 (63%)

Although the predicted exceedances are lower using the ISE model, both models still predict a high likelihood of elevated blood lead levels at this site.

Conclusions

Non-lead COPCs

Interpretation of risk characterization results is a matter of judgement by the risk manager. In general, USEPA considers that acceptable level of excess risk under RME assumptions is an HI equal to or less than one (1.0) for non-cancer risks. In this case, it is believed that there is no appreciable risk that noncancer health effects will occur. For cancer risks, it is the policy of the USEPA that remedial action is not warranted where excess cancer risks to the RME individual do not exceed a level of 100 excess cancer cases per one million people (USEPA 1991b).

The results of risk calculations presented in this report suggest that excess cancer or non-cancer risks to current residents may occur under RME exposure scenarios to soil, but are below a level of concern based on exposure to non-lead COPCs in drinking water. Risks to recreational users from exposure to non-lead COPCs in soils at non-residential areas are above a level of concern at all areas that were evaluated. For non-cancer, HI values for recreational visitors ranged from 2.0 to 3.9 under average exposure assumptions and from 9.3 to 17.9 under RME assumptions. For cancer risks under average exposure assumptions, no values were found to exceed a risk level of 100 per million. However, using RME assumptions these cancer risks ranged from 349 to 719 per million. Overall, these risks are primarily attributable to elevated concentrations of arsenic.

Elevated risks were predicted for hypothetical future residents at all evaluated exposure areas, indicating that adverse effects could occur to future residents of these current non-residential properties. For non-cancer, HI values for future residents ranged from 1.4 to 2.7 under average exposure assumptions and from 3.9 to 7.5 under RME assumptions. For cancer risks under average exposure assumptions, no values were found to exceed a risk level of 100 per million. However, using RME assumptions these cancer risks ranged from 367 to 756 per million. Overall, these risks are primarily attributable to elevated concentrations of arsenic.

Lead

The USEPA has identified 10 ug/dL as the blood lead level at which effects that warrant avoidance begin to occur, and has set as a goal that there should be no more than a 5% chance that any child will have a blood lead value above 10 ug/dL (P10 < 5%). Risks from lead exposure were evaluated at this site using both modeling approaches and direct blood lead observations. Using the IEUBK model, it was estimated that approximately 100% of the properties evaluated within Eureka and the outlying non-residential areas will have P10's exceeding this guideline. The majority of the current residential properties were estimated to have P10 levels exceeding 20%. This prediction of elevated blood lead levels is supported by findings of the blood lead investigation, in which 34% of the blood lead samples collected from children age 0-6 years were found to exceed 10 ug/dL.

An alternate model used to evaluate lead risks at this site, supports the prediction of the IEUBK model for elevated blood lead, but to a lesser extent. This model, known as the ISE model for lead, predicts that 63% of the current residential properties evaluated within Eureka will exceed EPA's guidelines.

Table ES-1: Summary Statistics for Data Set #1

Analyte	Analysis Method[+]	Detection Frequency (%)	Avg* (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	ICP	394/394 (100%)	11,826	1,100	20,000
Antimony	ICP	27/30 (90%)	19	10	59
Arsenic	ICP	394/394 (100%)	141	7.7	2,100
Barium	ICP	394/394 (100%)	326	91	1,200
Beryllium	ICP	394/394 (100%)	0.92	0.19	1.8
Cadmium	ICP	394/394 (100%)	19	0.5	140
Calcium	ICP	394/394 (100%)	49,968	5,200	250,000
Chromium	ICP	394/394 (100%)	17	2	110
Cobalt	ICP	394/394 (100%)	5.7	1.1	15
Copper	XRF	695/4211 (16%)	126	13	2,700
Iron	XRF	4208/4211 (99.9%)	19,649	5,600	88,000
Lead	XRF	3674/4211 (87%)	1,239	18	25,000
Magnesium	ICP	394/394 (100%)	18,741	2,100	84,000
Manganese	ICP	394/394 (100%)	1,054	220	5,100
Mercury	ICP	394/394 (100%)	3.3	0.04	130
Nickel	ICP	394/394 (100%)	12	3.4	34
Potassium	ICP	394/394 (100%)	3,346	390	6,200
Selenium	ICP	115/370 (31%)	0.79	0.5	8.3
Silver	ICP	351/384 (91%)	11	1	190
Sodium	ICP	394/394 (100%)	333	59	3,700
Thallium	ICP	53/391 (14%)	56	31	200
Vanadium	ICP	394/394 (100%)	26	7.7	330
Zinc	XRF	4068/4211 (97%)	1,460	26	44,000

* Non-Detects Evaluated at the Detection Limit

[+] XRF data used where deemed reliable, otherwise ICP data was used

Table ES-2: Summary Statistics for Data Set #2

Analyte	Analysis Method[+]	Non-Residential				Background			
		Detection Frequency (%)	Avg* (mg/kg)	Min (mg/kg)	Max (mg/kg)	Detection Frequency (%)	Avg* (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	ICP	36/36 (100%)	4,807	88	12,800	3/3 (100%)	9,583	7,240	11,700
Antimony	ICP	30/36 (83%)	43	0.5	330	0/3 (0%)	0.7	0.5	1.1
Arsenic	ICP	35/36 (97%)	414	0.4	1,100	3/3 (100%)	9.5	4.2	13.4
Barium	XRF	265/265 (100%)	622	57	3,600	18/18 (100%)	555	58	1,800
Beryllium	ICP	36/36 (100%)	0.56	0.1	1.4	3/3 (100%)	0.66	0.61	0.7
Cadmium	ICP	35/36 (97%)	60	0.2	171	3/3 (100%)	0.38	0.21	0.56
Calcium	XRF	265/265 (100%)	56,147	1,200	250,000	18/18 (100%)	41,295	1,200	132,000
Chromium	ICP	35/36 (97%)	14	0.3	220	3/3 (100%)	7.9	2.5	12.3
Cobalt	ICP	35/36 (97%)	5.65	0.2	17	3/3 (100%)	5.7	4.5	7.3
Copper	XRF	144/266 (54%)	279	74	2,200	0/18 (0%)	76	74	77
Iron	ICP	36/36 (100%)	21,774	61	48,500	3/3 (100%)	12,800	11,100	14,000
Lead	XRF	258/265 (97%)	4,065	32	51,000	17/18 (94%)	148	32	930
Magnesium	ICP	35/36 (97%)	22,950	23	79,000	3/3 (100%)	14,390	3,230	34,700
Manganese	ICP	36/36 (100%)	1,759	1	5,750	3/3 (100%)	441	117	710
Mercury	ICP	34/36 (94%)	10.2	0.05	144	2/3 (67%)	0.06	0.05	0.066
Nickel	ICP	34/36 (94%)	18	0.3	111	3/3 (100%)	9.5	1.9	16.9
Potassium	XRF	264/265 (99.6%)	16,277	2,200	35,000	18/18 (100%)	18,724	2,200	24,000
Selenium	ICP	35/36 (97%)	3.86	0.4	18	3/3 (100%)	0.97	0.8	1.2
Silver	ICP	32/36 (89%)	49	0.2	165	1/3 (33%)	0.2	0.2	0.2
Sodium	ICP	33/36 (92%)	758	42	1,830	0/3 (0%)	41.6	41.6	41.6
Thallium	ICP	27/36 (75%)	16	0.6	68	1/3 (33%)	0.77	0.6	1.1
Vanadium	ICP	35/36 (97%)	26	0.3	238	3/3 (100%)	23.2	15.6	31.8
Zinc	XRF	265/265 (100%)	4,198	54	26,000	16/18 (89%)	191	91	790

* Non-Detects Evaluated at the Detection Limit

[+] XRF data used where deemed reliable, otherwise ICP data was used

Table ES-3: Summary Statistics for Indoor Dust Analyzed via ICP

Analyte	Detection Frequency (%)	Avg (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	100%	7,562	2,770	14,900
Antimony	98%	5	0.2	20.5
Arsenic	100%	40	10.3	123
Barium	100%	282	70.8	2,060
Berylium	89%	0.4	0.14	1.9
Cadmium	100%	7.3	2	18.6
Calcium	100%	40,777	13,700	85,500
Chromium	100%	25	7.4	120
Cobalt	100%	3.8	1.1	11.8
Copper	100%	160	34.5	649
Iron	100%	9,429	3,300	27,300
Lead	100%	707	193	2,010
Magnesium	100%	10,930	3,460	20,800
Manganese	100%	436	123	1,530
Mercury	100%	0.7	0.1	2.7
Nickel	100%	19	7.6	50.4
Potassium	100%	6,472	2,480	14,800
Selenium	53%	1.6	0.67	17.8
Silver	100%	4.3	1.1	10.8
Sodium	98%	26,212	18.9	171,000
Thallium	79%	1.3	0.32	3.7
Vanadium	100%	16	5.6	24.2
Zinc	100%	1,201	372	5,490

N = 57
Non Detects evaluated at the Detection Limit

Table ES-4: Summary Statistics for Basement Soils Analyzed via ICP

Analyte	Detection Frequency (%)	Avg (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	7/7 (100%)	10,919	7,900	17,800
Antimony	1/7 (14%)	1.6	0.2	7.4
Arsenic	7/7 (100%)	29	6.8	131
Barium	7/7 (100%)	231	169	328
Beryllium	7/7 (100%)	0.7	0.61	0.87
Cadmium	7/7 (100%)	7.4	1.2	39.2
Calcium	7/7 (100%)	21,891	7,440	47,000
Chromium	7/7 (100%)	10	4.1	14.7
Cobalt	7/7 (100%)	5	3.4	6.4
Copper	7/7 (100%)	96	6.3	536
Iron	7/7 (100%)	15,843	10,100	29,200
Lead	7/7 (100%)	1,000	122	5,330
Magnesium	7/7 (100%)	5,234	3,090	8,990
Manganese	7/7 (100%)	481	282	732
Mercury	7/7 (100%)	2	0.14	10.3
Nickel	7/7 (100%)	11.5	5.1	17.9
Potassium	7/7 (100%)	2,763	1,970	3,680
Selenium	7/7 (100%)	1.3	0.28	4.9
Silver	7/7 (100%)	5.6	0.57	28
Sodium	6/7 (86%)	371	17.7	869
Thallium	5/7 (71%)	1.7	0.34	6.6
Vanadium	7/7 (100%)	20	14.9	26.9
Zinc	7/7 (100%)	1,293	147	5,730

Non Detects Evaluated at the Detection Limit

Table ES-5: Summary Statistics for Eureka Paint Stratified by Condition

Exterior

Condition	Detection Freq.	Detects (mg/cm2)		
		Min	Max	Avg
cracking	1/1 (100%)	0.15	0.15	0.15
loose	1/1 (100%)	0.01	0.01	0.01
NA	1/1 (100%)	0.12	0.12	0.12
non-painted	--	--	--	--
peeling	4/17 (24%)	0.01	1.4	0.515
tight	4/8 (50%)	0.01	1.4	0.463
All	11/28 (39%)	0.01	1.4	0.252

Interior

Condition	Detection Freq.	Detects (mg/cm2)		
		Min	Max	Avg
cracking	1/1 (100%)	0.03	0.03	0.03
loose	4/6 (67%)	0.01	0.04	0.023
NA	0/1 (0%)	--	--	--
non-painted	0/3 (0%)	--	--	--
peeling	7/16 (44%)	0.01	1.7	0.371
tight	30/91 (33%)	0.01	1.7	0.184
All	42/118 (36%)	0.01	1.7	0.152

Analysis method is Pb L Line (measured at the paint surface)

Analyzed via XRF

NA refers to sites where the paint condition was not recorded in the field log book

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Table ES-6: Summary Statistics for Tap Water Analyzed via ICP

Analyte	Detection Frequency (%)	Non-Detects Only (ug/L)			Detects Only (ug/L)		
		Avg	Min	Max	Avg	Min	Max
Aluminum	3/54 (6%)	29.4	19.3	34.9	36.7	31.6	43.5
Antimony	2/54 (4%)	1.94	1.9	2.3	2.15	2.1	2.2
Arsenic	25/54 (46%)	3.36	2.6	3.6	4.33	2.8	7.6
Barium	51/54 (94%)	2.09	0.38	3.5	103	82.1	129
Beryllium	0/54 (0%)	0.11	0.1	0.2	--	--	--
Cadmium	12/54 (22%)	0.29	0.2	0.51	0.70	0.34	2.2
Calcium	54/54 (100%)	--	--	--	69, 802	89	80, 800
Chromium	6/54 (11%)	0.65	0.5	1.4	0.80	0.51	0.94
Cobalt	0/54 (0%)	0.61	0.5	0.8	--	--	--
Copper	54/54 (100%)	--	--	--	281	6.3	1, 970
Iron	21/54 (39%)	23.2	10.8	100	123	12.4	471
Lead	19/54 (35%)	1.94	1.6	3.3	4.4 (excl. outlier)	2.1	38 (outlier) 13.8
Magnesium	53/54 (98%)	32.5	32.5	32.5	12703	223	14700
Manganese	33/54 (61%)	5.39	0.27	16.5	7.0	2.2	18.5
Mercury	2/54 (4%)	0.1	0.1	0.1	0.11	0.11	0.12
Nickel	45/54 (83%)	1.42	0.8	4.7	3.89	0.93	49.6
Potassium	53/54 (98%)	575	575	575	4787	383	5590
Selenium	5/54 (9%)	4.05	2.2	5	5.12	2.8	7.7
Silver	0/54 (0%)	0.89	0.6	3	--	--	--
Sodium	54/54 (100%)	--	--	--	33, 819	21800	130, 000
Thallium	3/54 (6%)	4.88	3.3	8.4	5.83	4.2	6.9
Vanadium	50/54 (93%)	3.83	3.5	4.2	3.99	1.3	4.8
Zinc	54/54 (100%)	--	--	--	501	45	4, 330

Table ES-7: Summary Statistics for Residential Surface Soils

Chemical	Location	Detect Frequency	Max Value (mg/kg)	Min Value (mg/kg)	Mean (mg/kg)	UCL95 Norm	UCL95 LogNorm	EPC (mg/kg)
Antimony	1	2/3	12.0	5.0	9.3	15.7	89.6	12.0
	2	0/1	5.0	5.0	5.0	--	--	5.0
	3	1/1	13.0	13.0	13.0	--	--	13.0
	4	--	--	--	--	--	--	--
	5	1/1	11.0	11.0	11.0	--	--	11.0
	6	--	--	--	--	--	--	--
	All	4/6	13.0	5.0	9.5	12.4	15.3	13.0
Arsenic	1	55/55	560	9.5	80.1	101	101	101
	2	32/32	260	12.0	71.6	90.4	99.1	99.1
	3	9/9	240	8.0	50.2	95.8	152	152
	4	32/32	290	7.7	90.1	109	123	123
	5	21/21	220	20.0	76.1	96.2	106	106
	6	--	--	--	--	--	--	--
	All	149/149	560.0	7.7	78.1	88.1	89.8	89.8
Cadmium	1	46/46	61.0	1.5	14.6	17.9	19.4	19.4
	2	29/29	39.0	1.9	9.5	12.0	12.6	12.6
	3	9/10	45.0	0.3	7.6	15.4	65.3	45.0
	4	27/27	40.0	1.4	14.5	17.6	20.7	20.7
	5	20/20	59.0	4.6	15.1	20.9	21.2	21.2
	6	--	--	--	--	--	--	--
	All	131/132	61.0	0.3	13.0	14.7	16.2	16.2
Iron*	1	546/546	32180	6112	18305	18534	18537	18537
	2	292/292	27907	7650	16137	16342	16349	16349
	3	142/142	19360	9958	15742	15996	16026	16026
	4	304/304	36454	10813	16936	17255	17209	17255
	5	283/283	39018	8847	16740	17040	17015	17040
	6	120/120	69787	11668	17707	18689	18103	18689
	All	1000/1000	32180	6112	17262	17418	17415	17418
Manganese	1	38/38	3500	220	921	1105	1094	1105
	2	29/29	3000	330	800	978	948	978
	3	10/10	2600	320	769	1171	1312	1312
	4	25/25	2500	430	917	1055	1044	1055
	5	18/18	1800	470	766	893	883	893
	6	--	--	--	--	--	--	--
	All	120/120	3500	220	855	939	915	939
Mercury	1	50/50	20.0	0.1	1.6	2.3	2.0	2.3
	2	29/29	7.6	0.1	1.1	1.6	1.8	1.8
	3	10/10	2.1	0.1	0.5	0.9	2.1	2.1
	4	29/29	10.0	0.2	2.1	2.8	3.4	3.4
	5	18/18	29.0	0.1	2.9	5.6	5.6	5.6
	6	--	--	--	--	--	--	--
	All	136/136	29.0	0.1	1.7	2.2	2.0	2.2

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Chemical	Location	Detect Frequency	Max Value (mg/kg)	Min Value (mg/kg)	Mean (mg/kg)	UCL95 Norm	UCL95 LogNorm	EPC (mg/kg)
Silver	1	46/48	29.0	0.5	6.6	8.2	9.1	9.1
	2	27/29	8.8	0.5	3.8	4.6	5.6	5.6
	3	4/5	13.0	0.5	4.2	9.1	221	13.0
	4	28/29	19.0	0.5	6.2	7.6	9.3	9.3
	5	22/22	56.0	1.5	10.3	15.3	17.2	17.2
	6	--	--	--	--	--	--	--
	All	127/133	56.0	0.5	6.4	7.5	7.6	7.6
Thallium	1	5/6	150	25.0	83.5	118	183	150
	2	0/2	25.0	25.0	25.0	25.0	25.0	25.0
	3	0/2	25.0	25.0	25.0	25.0	25.0	25.0
	4	1/3	54.0	25.0	34.7	62.9	184	54.0
	5	0/2	25.0	25.0	25.0	25.0	25.0	25.0
	6	--	--	--	--	--	--	--
	All	6/15	150	25.0	50.3	67.7	72.9	72.9

-- No data available

UCL = 95% upper confidence limit of the mean

EPC = Exposure Point Concentration, defined as the UCL or the maximum, whichever is lower

* Iron data is based on adjusted XRF dataset

Table ES-8: Summary Statistics for Indoor Dust

Chemical	Location	Detect Frequency	Max Value (mg/kg)	Min Value (mg/kg)	Mean (mg/kg)	UCL95 Norm	UCL95 LogNorm	EPC (mg/kg)
Antimony	1	18/19	20.5	0.7	6.5	8.5	10.2	10.2
	2	10/10	5.9	2.0	3.6	4.2	4.4	4.4
	3	--	--	--	--	--	--	--
	4	13/13	12.2	3.1	6.1	7.5	7.9	7.9
	5	8/8	7.6	2.2	5.0	6.4	7.5	7.5
	6	--	--	--	--	--	--	--
	All	50/51	20.5	0.7	5.5	6.4	6.5	6.5
Arsenic	1	23/23	123	10.3	42.7	50.9	55.7	55.7
	2	11/11	41.4	10.6	25.4	31.1	34.2	34.2
	3	--	--	--	--	--	--	--
	4	14/14	63.4	13.9	40.8	48.5	54.5	54.5
	5	8/8	73.5	19.4	42.8	54.6	62.9	62.9
	6	--	--	--	--	--	--	--
	All	57/57	123	10.3	39.7	44.2	45.8	45.8
Cadmium	1	21/21	12.4	2.0	7.7	8.8	9.4	9.4
	2	11/11	10.1	2.2	5.7	7.0	7.6	7.6
	3	--	--	--	--	--	--	--
	4	14/14	18.6	2.1	7.7	9.7	11.0	11.0
	5	8/8	13.6	3.4	8.0	10.2	11.9	11.9
	6	--	--	--	--	--	--	--
	All	55/55	18.6	2.0	7.4	8.1	8.4	8.4
Iron	1	21/21	14300	3300	9570	10718	11558	11558
	2	11/11	10900	4040	7798	9153	9861	9861
	3	--	--	--	--	--	--	--
	4	14/14	27300	4230	9993	12615	12956	12956
	5	7/7	12500	4730	9704	11745	13257	12500
	6	--	--	--	--	--	--	--
	All	54/54	27300	3300	9348	10196	10367	10367
Manganese	1	23/23	1530	123	469	566	590	590
	2	10/10	469	184	341	403	431	431
	3	--	--	--	--	--	--	--
	4	14/14	612	182	425	487	529	529
	5	8/8	710	184	490	608	730	710
	6	--	--	--	--	--	--	--
	All	56/56	1530	123	438	484	491	491
Mercury	1	21/21	2.7	0.2	0.7	1.0	1.0	1.0
	2	10/10	0.9	0.1	0.4	0.6	0.8	0.8
	3	--	--	--	--	--	--	--
	4	11/11	2.2	0.4	0.9	1.2	1.4	1.4
	5	7/7	0.9	0.1	0.5	0.7	1.0	0.9
	6	--	--	--	--	--	--	--
	All	50/50	2.7	0.1	0.7	0.8	0.8	0.8

Chemical	Location	Detect Frequency	Max Value (mg/kg)	Min Value (mg/kg)	Mean (mg/kg)	UCL95 Norm	UCL95 LogNorm	EPC (mg/kg)
Silver	1	19/19	10.6	1.1	4.6	5.5	6.2	6.2
	2	9/9	8.4	1.1	3.7	5.1	6.4	6.4
	3	--	--	--	--	--	--	--
	4	14/14	10.8	1.9	4.6	5.7	5.9	5.9
	5	8/8	5.9	3.4	4.4	5.0	5.2	5.2
	6	--	--	--	--	--	--	--
	All	51/51	10.8	1.1	4.4	4.9	5.0	5.0
Thallium	1	17/19	2.9	0.2	1.2	1.5	1.9	1.9
	2	4/8	1.2	0.2	0.6	0.8	1.7	1.2
	3	--	--	--	--	--	--	--
	4	11/13	3.6	0.2	1.4	2.0	3.9	3.6
	5	5/7	3.7	0.2	1.5	2.5	19.6	3.7
	6	--	--	--	--	--	--	--
	All	38/48	3.7	0.2	1.2	1.5	1.8	1.8

-- No data available

UCL = 95% upper confidence limit of the mean

EPC = Exposure Point Concentration, defined as the UCL or the maximum, whichever is lower

Table ES-9: Summary Statistics for Residential Tap Water

Chemical	Location	Medium	Detection Frequency	Max Value (ppb)	Min Value (ppb)	Mean (ppb)	UCL95		EPC (ppb)
							Norm	LogNorm	
Arsenic	All	Tap Water	25/54	7.6	1.3	2.9	3.3	3.3	3.3
Cadmium	All	Tap Water	12/54	2.2	0.1	0.3	0.3	0.3	0.3

Table ES-10: Summary Statistics for Non-Residential Surface Soils

Chemical	Location	Detect Frequency	Max Value (mg/kg)	Min Value (mg/kg)	Mean (mg/kg)	UCL95 Norm	UCL95 LogNorm	EPC (mg/kg)
Antimony	A	4/4	108	27.8	58.4	99.0	174	108
	B	--	--	--	--	--	--	--
	C	5/5	24.8	1.0	15.7	24.6	1422	24.8
	D	3/3	67.8	8.6	41.5	92.3	1.5E+06	67.8
	E	5/5	330	27.0	112	231	1220	330
	F	6/6	79.2	13.2	46.3	70.0	146	79.2
	G	--	--	--	--	--	--	--
	All	23/23	330	1.0	55.4	79.3	130	130
Arsenic	A	4/4	637	200	382	629	1181	637
	B	--	--	--	--	--	--	--
	C	5/5	533	2.4	273	488	7.0E+08	533
	D	3/3	861	78.7	468	1128	1.2E+09	861
	E	5/5	1080	246	788	1106	2290	1080
	F	6/6	1100	256	653	925	1358	1100
	G	--	--	--	--	--	--	--
	All	23/23	1100	2.4	529	649	1931	1100
Cadmium	A	4/4	171	38.6	75.0	151	346	171
	B	--	--	--	--	--	--	--
	C	5/5	136	0.2	53.4	118	2.9E+09	136
	D	3/3	59	29.2	42.6	68.4	162	59.3
	E	5/5	157	25.8	108	159	473	157
	F	6/6	120	39.8	75.1	98.0	112	112
	G	--	--	--	--	--	--	--
	All	23/23	171	0.2	73.3	91.6	396	171
Iron	A	4/4	34800	14700	26375	37368	49694	34800
	B	--	--	--	--	--	--	--
	C	5/5	31400	12800	23040	30693	39329	31400
	D	3/3	18800	15400	17333	20279	21219	18800
	E	5/5	39500	20300	28860	36320	40129	39500
	F	6/6	25600	16400	21200	23763	24297	24297
	G	--	--	--	--	--	--	--
	All	23/23	39500	12800	23661	26246	26703	26703
Manganese	A	4/4	2530	1400	1835	2420	2640	2530
	B	--	--	--	--	--	--	--
	C	5/5	3350	14.8	1389	2686	1.3.E+08	3350
	D	3/3	1230	492	874	1498	7739	1230
	E	5/5	5750	1920	4430	5895	8302	5750
	F	6/6	4050	1350	2108	3005	3498	3498
	G	--	--	--	--	--	--	--
	All	23/23	5750	15	2248	2829	6861	5750
Mercury	A	4/4	6.2	1.2	3.2	5.8	15.8	6.2
	B	--	--	--	--	--	--	--
	C	5/5	4.7	0.6	2.6	4.2	20.0	4.7
	D	3/3	144	1.7	71.5	192	3.3E+26	144
	E	5/5	6.3	2.7	4.3	5.6	6.3	6.3
	F	6/6	1.2	0.3	0.7	1.0	1.4	1.2
	G	--	--	--	--	--	--	--
	All	23/23	144	0.3	11.6	23.1	21.3	23.1

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Chemical	Location	Detect Frequency	Max Value (mg/kg)	Min Value (mg/kg)	Mean (mg/kg)	UCL95 Norm	UCL95 LogNorm	EPC (mg/kg)
Silver	A	4/4	109	6.2	44.4	96.9	3327	109
	B	--	--	--	--	--	--	--
	C	4/5	110	0.1	42.1	94.9	3.6E+11	110
	D	3/3	90.4	27.1	57.5	111	1744	90.4
	E	5/5	63.2	26.9	42.9	55.5	62.7	62.7
	F	6/6	138	14.9	75.9	116	275	138
	G	--	--	--	--	--	--	--
	All	22/23	138	0.1	53.5	68.3	428	138
Thallium	A	4/4	50.5	10.7	25.7	46.2	107	50.5
	B	--	--	--	--	--	--	--
	C	4/5	61.3	0.3	20.4	42.9	6.7E+05	61.3
	D	2/3	6.9	1.6	4.6	9.3	1956	6.9
	E	5/5	67.5	8.1	47.8	70.2	414	67.5
	F	6/6	27.0	6.8	12.9	19.2	23.3	23.3
	G	--	--	--	--	--	--	--
	All	21/23	67.5	0.3	23.3	31.1	66.4	66.4

-- No data available

UCL = 95% upper confidence limit of the mean

EPC = Exposure Point Concentration, defined as the UCL or the maximum, whichever is lower

Table ES-11: Risk Estimates for Residential Soil Ingestion (by area)

Part A: Evaluation of Chronic Non-Cancer Risk

Analyte	All Areas Avg	All Areas RME	Area 1 Avg	Area 1 RME	Area 2 Avg	Area 2 RME	Area 3 Avg	Area 3 RME	Area 4 Avg	Area 4 RME	Area 5 Avg	Area 5 RME	Area 6 Avg	Area 6 RME
Antimony	0.03	0.08	0.03	0.09	0.01	0.04	0.03	0.08	0.01	0.04	0.03	0.08		
Arsenic	0.15	0.43	0.18	0.49	0.14	0.40	0.19	0.52	0.21	0.57	0.20	0.56		
Cadmium	0.02	0.04	0.02	0.05	0.01	0.04	0.03	0.09	0.02	0.06	0.02	0.06		
Iron	0.06	0.16	0.06	0.18	0.06	0.16	0.03	0.09	0.06	0.18	0.06	0.18	0.04	0.10
Manganese	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02		
Mercury	0.01	0.02	0.01	0.02	0.00	0.01	0.01	0.02	0.01	0.03	0.01	0.03		
Silver	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01		
Thallium	0.23	0.64	0.27	0.77	0.19	0.54	0.20	0.56	0.23	0.64	0.22	0.61		
Total	0.50	1.40	0.58	1.63	0.43	1.21	0.50	1.39	0.55	1.54	0.55	1.54	0.04	0.10

Part B: Evaluation of Cancer Risk

Analyte	All Areas Avg	All Areas RME	Area 1 Avg	Area 1 RME	Area 2 Avg	Area 2 RME	Area 3 Avg	Area 3 RME	Area 4 Avg	Area 4 RME	Area 5 Avg	Area 5 RME	Area 6 Avg	Area 6 RME
Arsenic	9	83	10	95	8	77	11	101	12	111	12	108		
Total	9	83	10	95	8	77	11	101	12	111	12	108		

Blank cells indicate no data is available to evaluate risk
Shading indicates a value exceeding a level of concern (non-cancer: HI>1.0; cancer: Risk>100/million)
Cancer risks are out of a million

Table ES-12: Risk Estimates for Residential Consumption of Tap Water

Part A: Evaluation of Chronic Non-Cancer Risk

Analyte	All Areas	
	Avg	RME
Arsenic	0.18	0.38
Cadmium	0.01	0.02
Total	0.19	0.40

Part B: Evaluation of Cancer Risk

Analyte	All Areas	
	Avg	RME
Arsenic	11	73
Total	11	73

Cancer risks are out of a million

Table ES-13: Risk Estimates at Non-Residential Areas

RECREATIONAL USER

Part A: Evaluation of Chronic Non-Cancer Risk

Analyte	Area A Avg	Area A RME	Area B Avg	Area B RME	Area C Avg	Area C RME	Area D Avg	Area D RME	Area E Avg	Area E RME	Area F Avg	Area F RME	Area G Avg	Area G RME
Antimony	0.27	1.25			0.06	0.29	0.17	0.78	0.83	3.82	0.20	0.92		
Arsenic	1.17	5.40			0.98	4.52	1.58	7.30	1.98	9.16	2.02	9.33		
Cadmium	0.17	0.79			0.14	0.63	0.06	0.27	0.16	0.73	0.11	0.52		
Iron	0.12	0.54												
Manganese	0.02	0.08			0.02	0.11	0.01	0.04	0.04	0.19	0.02	0.12		
Mercury	0.02	0.10			0.02	0.07	0.48	2.22	0.02	0.10	0.00	0.02		
Silver	0.02	0.10			0.02	0.10	0.02	0.08	0.01	0.06	0.03	0.13		
Thallium	0.63	2.92			0.77	3.54	0.09	0.40	0.84	3.90	0.29	1.35		
Total	*2.42*	*11.18*			*2.00*	*9.26*	*2.40*	*11.10*	*3.88*	*17.95*	*2.67*	*12.37*		

Part B: Evaluation of Cancer Risk

Analyte	Area A Avg	Area A RME	Area B Avg	Area B RME	Area C Avg	Area C RME	Area D Avg	Area D RME	Area E Avg	Area E RME	Area F Avg	Area F RME	Area G Avg	Area G RME
Arsenic	45	417			38	349	61	563	76	706	78	719		
Total	45	417			38	349	61	563	76	706	78	719		

FUTURE RESIDENTIAL

Part A: Evaluation of Chronic Non-Cancer Risk

Analyte	Area A Avg	Area A RME	Area B Avg	Area B RME	Area C Avg	Area C RME	Area D Avg	Area D RME	Area E Avg	Area E RME	Area F Avg	Area F RME	Area G Avg	Area G RME
Antimony	0.19	0.53			0.04	0.12	0.12	0.33	0.57	1.60	0.14	0.39		
Arsenic	0.81	2.27			0.68	1.90	1.10	3.07	1.38	3.85	1.40	3.92		
Cadmium	0.12	0.33			0.09	0.26	0.04	0.12	0.11	0.31	0.08	0.22		
Iron	0.08	0.23												
Manganese	0.01	0.04			0.02	0.05	0.01	0.02	0.03	0.08	0.02	0.05		
Mercury	0.01	0.04			0.01	0.03	0.33	0.93	0.01	0.04	0.00	0.01		
Silver	0.02	0.04			0.02	0.04	0.01	0.04	0.01	0.02	0.02	0.05		
Thallium	0.44	1.23			0.53	1.49	0.06	0.17	0.59	1.64	0.20	0.57		
Total	*1.68*	*4.70*			*1.39*	*3.90*	*1.67*	*4.67*	*2.70*	*7.55*	*1.86*	*5.20*		

Part B: Evaluation of Cancer Risk

Analyte	Area A Avg	Area A RME	Area B Avg	Area B RME	Area C Avg	Area C RME	Area D Avg	Area D RME	Area E Avg	Area E RME	Area F Avg	Area F RME	Area G Avg	Area G RME
Arsenic	47	438			39	367	64	592	80	743	81	756		
Total	47	438			39	367	64	592	80	743	81	756		

Blank cells indicate no data is available to evaluate risk

Shading indicates a value exceeding a level of concern (non-cancer: HI>1.00; cancer: Risk>100/million)

Cancer risks are out of million

I:/Eureka/RA Report/ Sept 2002 Final/ES Tables.wpd

Table ES-14: Summary Statistics for the IEUBK Model

All Residential Properties

Area	Count	Min PbB	Max PbB	Avg PbB	GSD 1.6		GSD 1.4	
					Avg P10	P10>5	Avg P10	P10>5
1	218	6.1	46.6	14.8	69.2	100%	72.1	100%
2	93	5.1	25.3	11.3	53.2	100%	53.6	96%
3	6	5.1	27.7	14.4	56.5	100%	55.5	83%
4	116	5.5	42.7	17.6	77.3	100%	80.6	98%
5	61	5.9	43.2	16.5	74.6	100%	78.3	100%
6	11	6.9	33.9	16.6	74.4	100%	78.7	100%
Total	505	5.1	46.6	15.0	68.7	100%	71.3	99%

Table ES-15: IEUBK Results for Future Residential Children at Non-Residential Areas

Outside Area	Predicted PbB (ug/dL)	P10 (%)	
		GSD = 1.6	GSD = 1.4
1	--	--	--
2	8.0	32	26
3	24.2	97	100
4	42.7	100	100
5	81.5	100	100
6	17.1	87	94
7	38.6	100	100
8	33.4	99	100
9	51.0	100	100
10	26.6	98	100
11	53.3	100	100
12	17.5	88	95
13	38.3	100	100
14	43.6	100	100
15	18.2	90	96
16	41.3	100	100
17	32.8	99	100
18	37.7	100	100
19	27.2	98	100
20	57.5	100	100
21	26.2	98	100
22	33.2	99	100
23	6.3	16	8
24	18.2	90	96
25	26.4	98	100
Avg	**33.4**	**91.3**	**92.3**

-- No conc data available

Table ES-16: Bower's Model Predictions for Recreational Visitors

Area #	Avg Surface Soil Concentration (mg/kg)	GM PbB (ug/dL)	95th Percentile PbB (ug/dL) GSD = 1.8
01	--	--	--
02	615	3.5	9.1
03	4,694	12.6	33.2
04	13,261	31.8	84
05	42,987	98.4	259
06	2,584	7.9	20.7
07	10,989	26.7	70
08	8,404	20.9	55.0
09	18,506	43.6	115
10	5,556	14.5	38.2
11	20,041	47.0	124
12	2,682	8.1	21.3
13	10,827	26.4	69.3
14	13,827	33.1	87
15	2,881	8.6	22.5
16	12,479	30.1	79
17	8,121	20.3	53.4
18	10,546	25.7	67.6
19	5,811	15.1	39.8
20	23,039	53.7	141
21	5,439	14.3	37.6
22	8,344	20.8	54.7
23	313	2.8	7.4
24	2,868	8.5	22.4
25	5,491	14.4	37.9
All	10,013	24.5	64.5

Table ES-17: Blood Lead Summary Statistics

Age	EUREKA						NHANES*	
	N	GM	MIN	MAX	N>10	% > 10	GM	% > 10
<1	3	5.0	3	9.5	0	0.0	--	--
1-2	17	9.1	2.5	18.5	8	47.1	4.1	11.5
3-5	31	7.2	1.6	32.2	10	32.3	3.4	7.3
6-11	50	6.6	1.8	42.4	13	26.0	2.5	4.0
12-19	32	3.1	0.9	21	2	6.3	1.6	1.6
20-49	65	2.6	0.9	35.1	1	1.5	2.6	3.3
50-69	20	3.9	0.9	12.7	1	5.0	4	7.0
$\geq$ 70	5	2.8	1.2	6.7	0	0.0	4	6.3
ALL	227	4.4	0.9	42.4	35	15.4	2.8	4.5

* Brody et al., 1994; Pirkle et al., 1994

Table ES-18: Observed and Predicted Blood Lead in Children

Area	Children Tested	Children with PbB>10	Avg PbB ug/dL	Predicted Avg PbB ug/dL	GSD 1.6 Avg P10 (%)	GSD 1.6 P10>5	GSD 1.4 Avg P10 (%)	GSD 1.4 P10>5
1	33	12	8.8	12.2	59.6	94%	61.7	94%
2	15	5	10.6	8.2	32.7	93%	29.6	80%
3	0	--	--	--	--	--	--	--
4	6	1	7.2	10.9	49.0	100%	48.8	100%
5	5	2	8.0	9.2	42.9	100%	42.4	80%
6	0	--	--	--	--	--	--	--
Total	59	20	9.1	10.8	50.3	95%	50.6	90%

-- No data available

Figure ES-1
Eureka Site Location
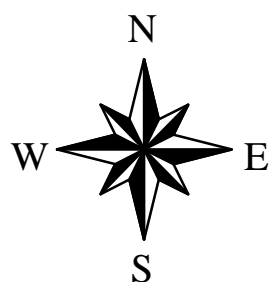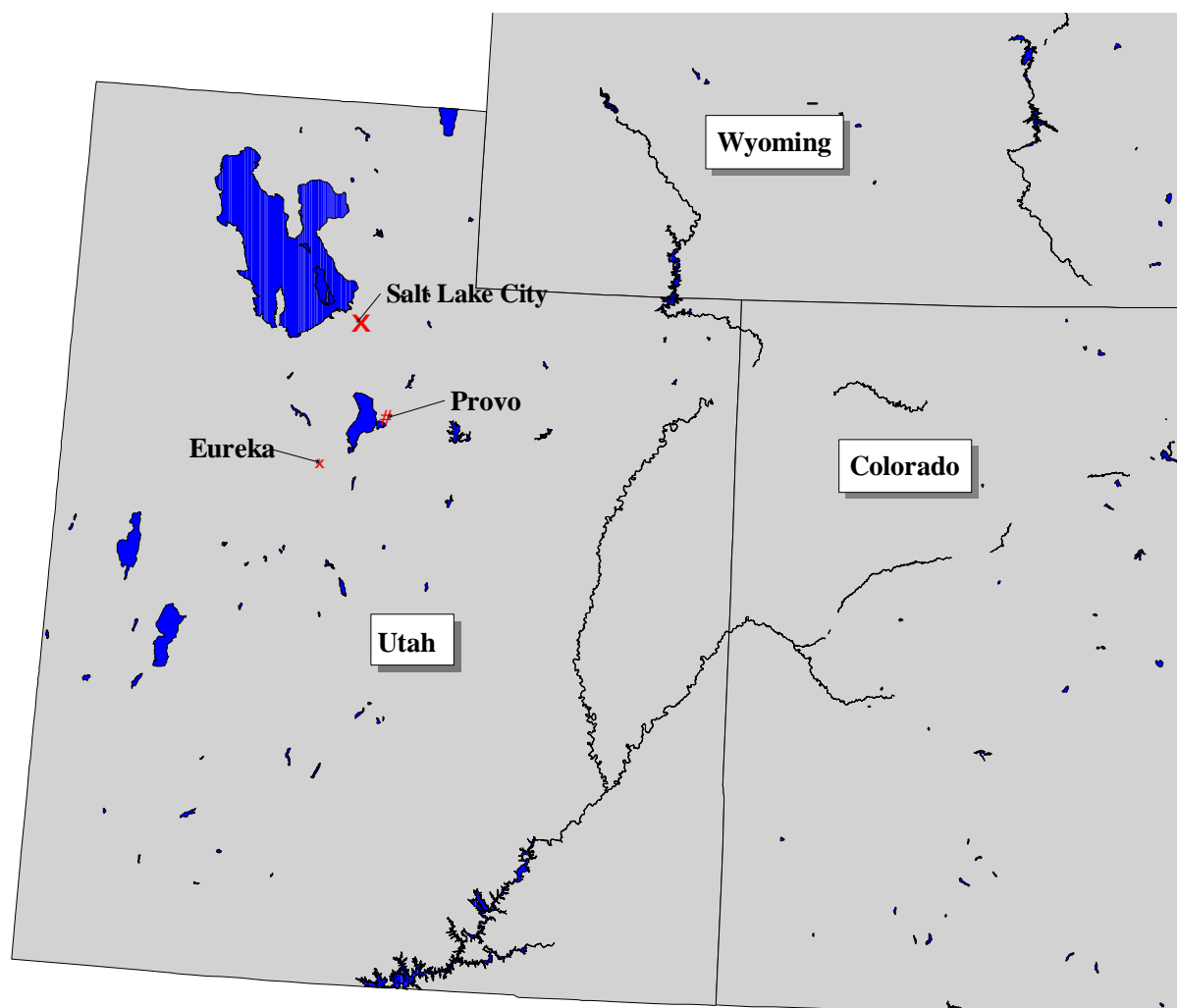
Figure ES-2
Sampling Locations for Speciation Analysis

Exposure Area 1

Exposure Area 2

Exposure Area 3

Exposure Area 6

Exposure Area 5
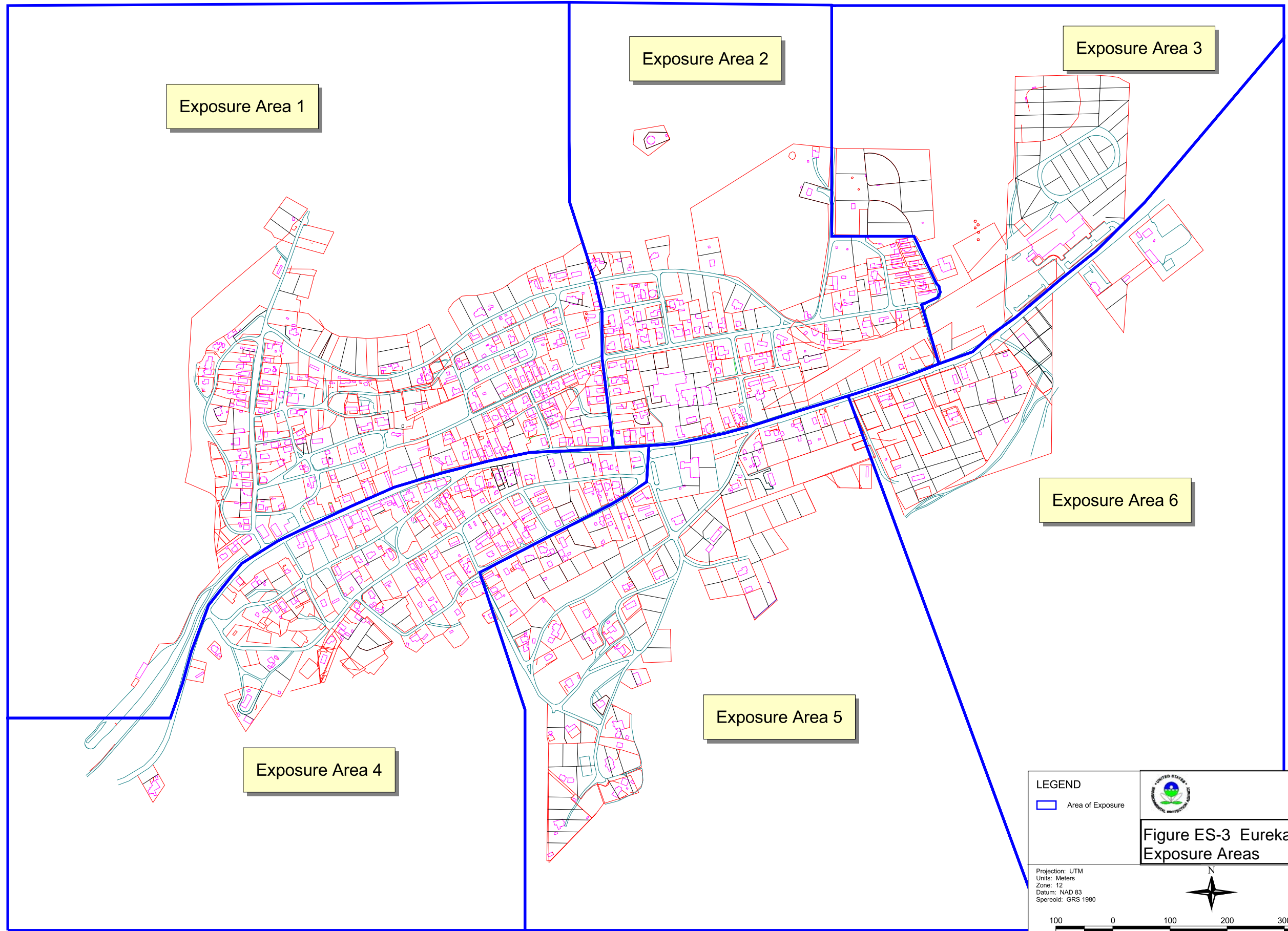
Exposure Area 4

LEGEND

Area of Exposure

Figure ES-3 Eureka Residential
Exposure Areas

Projection: UTM
Units: Meters
Zone: 12
Datum: NAD 83
Spereoid: GRS 1980

N

100   0   100   200   300   400 Meters

Figure ES-4: Observed vs Predicted Pb for Children (0-6 yrs)

$y = 0.1074x + 9.8287$

$R^2 = 0.0209$
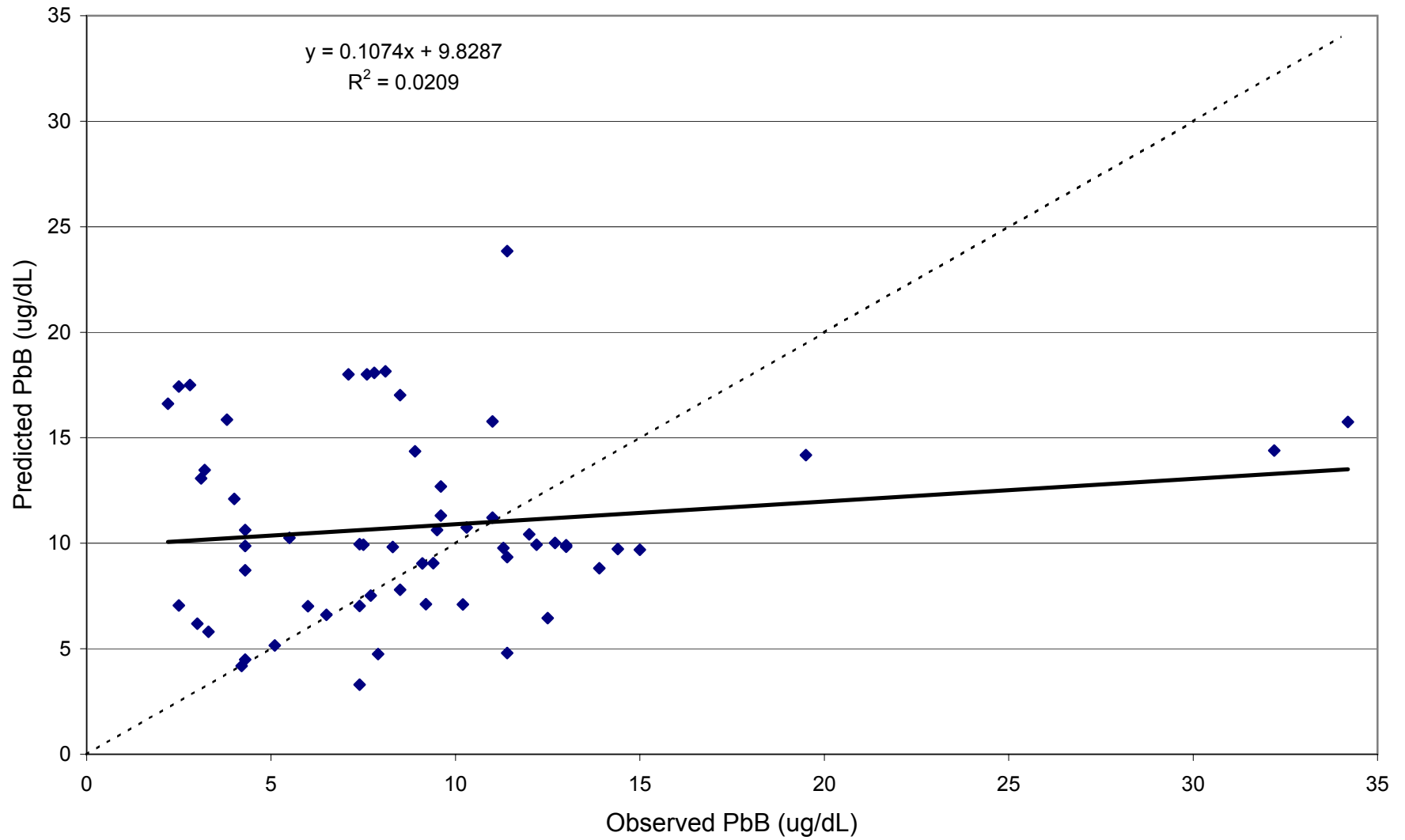
1.0   INTRODUCTION

1.1   Site Description and History

The town of Eureka, Utah, is located in the East Tintic Mountains approximately 70 miles south of Salt Lake City and 40 miles west of Provo (Figure 1-1). The Tintic district is the second-most productive base- and precious-metal mining district in Utah (Morris and Mogensen 1978). The district was discovered in 1869, and a smelter as well as a number of mills were built between 1871 and 1902. The Bullion Beck, Eureka Hill, Chief Consolidated, May Day, Godiva, and Uncle Sam were the most important mines in the area (UDEQ 2000).   Milling and mining activities were conducted in the area until 1965, and large waste piles resulting from these operations are common landscape attributes in and around the town of Eureka. Only sporadic mining activity has occurred at the site since 1965 (Morris and Mogensen 1978; UDEQ 2000).

1.2   Basis for Potential Health Concern

In July 2000, the Utah Department of Environmental Quality Division of Environmental Response and Remediation (UDEQ/DERR) collected a limited number (N=49)of soil and sediment samples from multiple locations around the Eureka Mills Site (UDEQ 2000). Elevated concentrations of lead (ranging up to 47,800 ppm) were observed in site soils. Because these values are well above the U.S. Environmental Protection Agency's (USEPA's) default level of concern for residents (400 ppm), and because these elevations occur in close proximity to residents of Eureka, it was determined that a threat to human health and the environment is present at this site. As a result, EPA began a Removal Evaluation at this site on August 28, 2000.

1.3   Purpose and Scope of this Risk Assessment

The purpose of this document is to utilize data collected during the Removal Evaluation to characterize the nature and magnitude of risks which mining-related wastes pose to humans who may be exposed in the vicinity of the site.

This risk assessment focuses on residents (current and future) and recreational visitors to the site. Based on experience at numerous other mining and smelting sites in the western United States, the chemicals of chief health concern to humans at mining sites are metals, so this evaluation focuses on the potential risks from these contaminants. The environmental medium of chief concern is contaminated area soils, as well as other media (e.g., indoor dust, home-grown vegetables) that may have become contaminated from the soil.

Information from this report will be used by risk managers to help make decisions as to whether the level of health risk posed by the mining/smelting related wastes is above acceptable limits, and if so, to help decide what actions are needed to protect public health.

1.4   Organization of This Document

In addition to this introduction, this report is organized into the following sections:

Section 2   This section provides a summary of the available data on the levels of chemical contaminants (metals) in site soils, and identifies which of these chemicals are of potential health concern to area residents.

Section 3   This section discusses how residents may be exposed to site-related chemicals, now or in the future, and identifies exposure scenarios that are considered to be of potential concern.

Section 4   This section assesses the level of exposure and risk to humans from non-lead chemicals of potential concern at this site. This includes 1) a description of methods used to quantify exposure to these chemicals, 2) data on the toxicity of these chemicals to humans, 3) calculation of the level of noncancer and cancer risk that may occur as a result of exposure to these chemicals in site soils, and 4) a discussion of the uncertainties which limit confidence in the assessment.

Section 5   This section assesses the level of exposure and risk to area residents from lead in site soils. This includes 1) a description of the toxic effects of lead, 2) a summary of the method used by USEPA to evaluate risks from lead, 3) a summary of the estimated risks at this site attributable to lead in site soils, and 4) a discussion of the uncertainties which limit confidence in the assessment.

Section 6   This section summarizes the overall findings presented in Sections 4 and 5.

Section 7   This section provides full citations for USEPA guidance documents, site-specific studies, and scientific publications referenced in the risk assessment.

2.0   DATA SUMMARY AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

As part of the Removal Assessment conducted at this site (URS 2000), a variety of environmental samples were collected from locations within Eureka during August and September 2000. These samples included soils (residential and mine waste areas), indoor dust, earthen basement soils, interior and exterior paint, and tap water. All data are provided in the electronic disk attached to this report.

2.1   Soil Data

Soil data collected during the Removal Assessment were obtained in two data sets that differed in location, analytes, and laboratories. Data set #1 contains analytical results for soil samples collected from residential properties. Data set #2 contains results for soils collected from background locations and non-residential (primarily mine-waste) areas surrounding Eureka. These two sets are described and evaluated separately below. Figure 2-1 shows sampling locations for both residential and non-residential soils.

2.1.1   Data Set 1 (Residential Soils)

This sampling effort is described in the site sampling and analysis plan (URS 2000). In brief, the Bureau of Reclamation (BOR) collected soil samples from over 500 residential properties within Eureka (Figure 2-2). Prior to soil collection, each residential property was divided into zones no greater than 15,000 square-feet (ft^2) in size. Properties smaller than this were treated as one zone, whereas larger properties were divided into two or more zones based upon local site conditions and remedial design considerations. Two composite surface samples (0-2") and three discrete depth samples (2-6", 6-12", 12-18") were collected from within each zone. A total of 4,211 residential soils were collected at this site. All samples were analyzed for 13 metals by X-ray Fluorescence Spectroscopy (XRF), and approximately 10% (N= 394) of these samples were also analyzed by Inductively Coupled Plasma Spectroscopy (ICP) for 23 metals. Summary statistics for these analyses are shown in Appendix A.

These XRF data underwent a data quality assessment (presented in Appendix A). In brief, the detection limits (DLs) obtained by XRF were compared to levels needed for risk assessment purposes. Additionally, a comparison of XRF vs ICP data was performed. In order for a data set to be judged reliable for use in the risk assessment, both the DL and correlation with ICP had to be listed as adequate. Further details of the data quality assessment can be found in Appendix A. Summary statistics for data carried through to COPC selection are shown in Table 2-1.

2.1.2   Data Set 2 (Soils from Non-Residential Areas)

This sampling effort is described in the site sampling and analysis plan (URS 2000). In brief, URS Operating Services, Inc. (UOS) collected soil samples from 7 nearby background locations and 25 non-residential (primarily mine-waste) areas around the perimeter of Eureka. Background locations

were selected based on a determination that the area appeared to have received no impact from mining activities. Samples at these areas were collected at depths of 0-6", 6-12" and 12-18". The non-residential areas (shown in Figure 2-3) were primarily identified based on the existence of visible mine waste piles, however two areas proposed as future residential properties were also sampled (Area 6 & 25). As shown, many of these non-residential areas were divided into one or more zones. Two composite surface samples (0-2") and three discrete depth samples (2-6", 6-12", 12-18") were collected from within each zone. A total of 265 non-residential soils were collected during this sampling effort at this site. All samples were analyzed for 26 metals by XRF, and approximately 13% (N= 36) of these samples were also analyzed by ICP for 23 metals. Summary statistics for these analyses are shown in Appendix A.

These XRF data underwent a data quality assessment (presented in Appendix A). In brief, the detection limits (DLs) obtained by XRF were compared to levels needed for risk assessment purposes. Additionally, a comparison of XRF vs ICP data was performed. In order for a data set to be judged reliable for use in the risk assessment, both the DL and correlation with ICP had to be listed as adequate. Further details of the data quality assessment can be found in Appendix A. Summary statistics for data carried through to COPC selection are shown in Table 2-2.

2.2   Indoor Dust

Indoor dust samples were obtained from a total of 57 residences within the study area. Samples were a single composite collected from three one-square-meter areas within each residence using an HVS3 vacuum as described in the site sampling and analysis plan (URS 2000). Dust samples were analyzed via ICP for 23 metals. Summary statistics for measured concentrations are provided in Table 2-3. Inspection of this table shows that the majority of the analytes were detected in 80 - 100% of the samples, with only selenium having a low detection frequency (53%). Based on the low detection frequency observed for selenium, concentrations reported for this chemical were compared to the level required to assess risk. The reported range of concentration values for selenium in dust (0.67 - 17.8 mg/kg) is below the Region 3 RBC of 39 mg/kg for soil (based on a HQ of 0.1), indicating the DL is adequate for risk assessment purposes.

Analyte	Reported Range (mg/kg)	RBC (mg/kg) (Region 3, HQ = 0.1)	DL Adequate?
Selenium	0.67 - 17.8	39	YES

2.3   Basement Soils

Composite soil samples (0-2") were collected from the basements of 7 homes which were observed to have earthen basements. Summary statistics for 23 metals in samples analyzed by ICP are presented in Table 2-4. As seen, the majority of these metals were detected in 80-100% of the samples analyzed. Antimony and thallium had detection frequencies of 14% and 71%, respectively. Therefore, the concentration ranges observed for the non-detects in these two chemicals were compared to corresponding RBC values as presented below. As shown, the detection limits for both chemicals were judged to be adequate for risk assessment purposes.

Analyte	DL Range (mg/kg)	RBC (mg/kg) (Region 3, HQ = 0.1)	DL Adequate?
Antimony	0.2 - 0.93	3.1	YES
Thallium	0.34-0.52	0.55	YES

2.4   Paint

Analysis of lead levels in paint was conducted at 23 residential properties. Concentrations were measured by field portable XRF at multiple locations (N=146) on both interior and exterior surfaces. A total of 51 samples were found to have concentrations below the detection limit (about 0.01 mg/cm^2). Of the remaining samples the mean detected value in all interior samples was 0.152 mg/cm^2, with a range of 0.01 to 1.7 mg/cm^2. For exterior samples, the mean was 0.252 mg/cm^2, with a range of 0.01 to 1.4 mg/cm^2. A total of 8 out of 146 samples had values above 1 mg/cm^2, the national default screening level for leaded paint (HUD 1995). These elevated samples were from both interior (N=4) and exterior (N=4) locations at 6 unique properties. Four of the samples were of peeling paint and the other four were on intact ("tight") paint. Of the 6 properties with elevated paint lead values, two had individuals who consented to release demographic information. Both of these properties were home to at least one child under age six. These data suggest that, at a few locations, interior and/or exterior leaded paint might be a source of lead exposure in area children, either directly (by paint chip ingestion), or indirectly (by ingestion of dust or soil containing paint-derived lead). Table 2-5 provides summary statistics for interior and exterior paint stratified by observed condition (e.g., peeling, tight).

2.5   Tap Water

First draw tap water samples were collected from a total of 54 residential properties. Samples were analyzed for 23 metals by ICP. Summary statistics are provided in Table 2-6. Inspection of this table shows a number of analytes were never detected (beryllium, cobalt, silver) or were detected only infrequently (aluminum, antimony, cadmium, chromium, mercury, selenium, thallium). Because it is

possible that the detection limit obtained in this analysis may have been too high for some analytes, the DL ranges were compared to levels needed for risk assessment purposes. This comparison is presented in Table 2-7. As shown, of the 23 chemicals, all were found to have DLs acceptable for risk assessment except arsenic and thallium. The detection limit for antimony was judged to be marginally acceptable, since 96% of the samples were non-detects and the DL range was close to the RBC based on an HQ of 0.1.

Due to concerns over the high detection limit for thallium, USEPA collected 10 additional tap water samples from Eureka households and submitted these for analysis at a lower detection limit. Thallium was not detected in any sample at a detection limit of 1 ug/L. Although this concentration is above the RBC value of 0.26 ug/L shown in Table 2-7 (based on HQ = 0.1), all samples were below a value of 2.6 ug/L, which is equivalent to an HQ of 1.0.

2.6   Physical-Chemical Characterization of Site Soils

In addition to the environmental sampling program described above, USEPA also undertook a study to characterize the physical and chemical attributes of lead and arsenic contamination in site soils. The main findings are summarized below. Full results for these analyses are provided in Appendix B.

2.6.1   Speciation of Arsenic and Lead

Most metals, including arsenic and lead, can occur in a variety of different chemical and physical forms. These differences are of potential significance not only because they may help identify the source of contamination, but also because the toxicity of the metals may differ between different chemical forms. Therefore, USEPA undertook a study to obtain data on the chemical forms of arsenic and lead present in site soils.

In brief, a set of 17 site soils were chosen for analysis, spanning a range of arsenic and lead concentration values. Locations for each sample are shown in Figure 2-4. Each sample was analyzed by electron microprobe analysis (EMPA), and the number and size of different chemical forms ("phases") of arsenic and lead-bearing particles were measured. From these data, the fraction of the total mass of arsenic and lead present in each phase was calculated.

The results are shown in Figures 2-5 and 2-6. As shown, arsenic occurs mainly in the iron oxide and lead-arsenic oxide phases, with a smaller fraction present in iron sulfate. In most samples, the majority of all arsenic-bearing particles were found to be <100 um in diameter. Lead occurs primarily as cerussite. The concentration of lead in this phase tends to increase as the total concentration of lead increases, suggesting this is the predominant form accounting for elevated lead levels. In most samples, the majority of lead-bearing particles are 5-100 um in diameter.

2.6.2   In Vitro Bioaccessability

Bioaccessability testing for lead and arsenic was also performed on the same soils selected for speciation analysis. Bioaccessability tests are performed in glass vessels ("in vitro") in the laboratory, and are designed to measure the relative solubility of a chemical under specified laboratory test conditions. Thus, *in vitro* solubility may not be equal to absorption observed *in vivo*. Preliminary results have shown that the results obtained using *in vitro* methods for lead bioaccessability can be correlated with results observed *in vivo*. Because a clear quantitative relationship between *in vitro* and *in vivo* values for arsenic has not yet been established, the *in vitro* results should not be assumed to be equivalent to a direct estimate of bioavailability in animals.   However, chemicals that are not readily dissolved from soil *in vitro* are also likely to be absorbed relatively slowly *in vivo*. Results are shown in Tables 2-8 (arsenic) and 2-9 (lead). As shown, bioaccessability for arsenic in these samples ranged from 4 to 42%. The bioaccessability for lead in these samples was observed to range from 60 to 89%.

2.7   Selection of Chemicals of Potential Concern

Chemicals of potential concern (COPCs) are chemicals which a) are present at a site, b) occur at concentrations which are or might be of health concern to exposed humans, and c) are or might be due to releases from a Superfund site.   USEPA has derived a standard method for selecting COPCs at a site, as detailed in *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual (Part A)* (USEPA 1989a).   Additionally, regional-specific guidance has been developed by USEPA Region 8 (1994) for use in the selection of COPCs. In brief, USEPA assumes that any chemical detected at a site is a candidate for selection as a COPC, but identifies a number of methods that may be used for determining when a chemical is not of concern and may be eliminated from further consideration. Each risk assessment may choose to apply some or all of the methods identified by USEPA to select COPCs, as appropriate.

Data collected during the preliminary sampling at the site clearly indicated that lead was a chemical of potential concern. However, at that time no systematic evaluation had been performed to determine whether or not any other chemicals might also be of potential concern. For this reason, a careful review of the available data was undertaken to determine if other chemicals should be added to the list. This review is summarized below.

<u>Soils</u>

As noted in Appendix A, the XRF data from Data Sets #1 and #2 are not reliable for a number of analytes, and not all chemicals were analyzed by this method. Therefore, the majority of the COPC selection process for soils was based on ICP data. However, in the cases where chemicals were only analyzed via XRF, the XRF data were used in the COPC selection process. Even though the ICP data sets include only 10% of all sample locations, this approach still incorporates values from 430 samples (394 from Data Set 1 and 36 from Data Set 2). Thus, this set is

considered reliable for identifying chemicals requiring evaluation in this risk assessment. Additionally, due to the conservatism built into the COPC screening process, it is not thought that any chemical posing a true health risk at this site would be inappropriately eliminated using the ICP subset of data. As discussed previously, these ICP data sets contain analytical results for a total of 23 chemicals.

Tap Water

The full tap water data set collected at this site was utilized to screen for COPC's. This data set contains analytical results for a total of 23 chemicals.

Step 1. Evaluation of Essential Nutrients

In accord with USEPA guidance (1989a, 1994), chemicals that are normal constituents of the body and the diet and are required for good health may be eliminated unless there is evidence that site-specific releases have elevated concentrations into a range where intakes would be potentially toxic. Of the chemicals analyzed in soils and water at this site, 11 are classified as essential nutrients (calcium, cobalt, chromium, copper, iron, magnesium, manganese, potassium, selenium, sodium, and zinc). Therefore, the assumed intakes of these 11 constituents in site soils were compared to their corresponding toxicity value or safe nutritive level as provided in USEPA 1994. For soil, ingestion of 200 mg/d for 6 years (as child) and 100 mg/d for 24 years (as adult) for 350 days/yr was assumed. For water, ingestion of 1 L/d for 6 years (as child) and 2 L/d for 24 years (as adult) for 350 days/yr was assumed. This resulted in intake factors of 3.7E-06 mg/kg-day and 3.5E-02 L/kg-day for soil and water intake, respectively. These values were then multiplied by the maximum detected concentration of a chemical in each media to obtain a daily intake for that chemical. This intake was then divided by the screening value provided by USEPA (1994) to determine if the chemical could be eliminated from further analysis based on an observed ratio of less than 1.0 (ie., predicted intake does not exceed safe level).

Results are summarized in Table 2-10. As shown, of the 11 essential nutrients analyzed in site soils, 9 may be eliminated from further analysis. Iron and manganese in soils will be evaluated further in the COPC selection process. For water, ten of these 11 chemicals were found to be below a level of concern and were therefore eliminated from further consideration. Copper in water will be evaluated further in the COPC selection process.

Step 2: Evaluation of Detection Frequencies

A contaminant with a detection frequency of $\geq$5% is carried through the toxicity/concentration screening process (Step 3). Chemicals having detection frequencies of <5% are usually assumed to be non-site related and are generally not evaluated as COPCs. However, it is important to ensure that the detection limit for such chemicals would have been adequate to detect the chemical if it were present at levels of human health concern. Of the chemicals analyzed via ICP in

site soils, the majority had detection frequencies >5%. Of the chemicals analyzed via XRF only (molybdenum, rubidium, strontium, thorium, tin, titanium, uranium, and zinc), three were observed in soils with a detection frequency below 5% (shown in Appendix A): molybdenum, tin, and uranium. Appendix A shows that the detection limits for these chemicals were adequate for risk assessment purposes. Additionally, the range of values detected in non-residential areas were similar to the ranges detected in soils from background areas, suggesting that any molybdenum, tin, or uranium detected on-site was due to natural background concentrations. Thus, molybdenum, tin and uranium were eliminated as COPCs in soil.

The chemicals with detection frequencies less than 5% observed in tap water (shown previously in Table 2-7) are antimony, beryllium, cobalt, mercury, and silver. As seen in Table 2-7, a review of the detection limits for these five infrequently detected chemicals revealed that the reported detection limits were adequate for risk assessment purposes. Additionally, reevaluation of thallium in tap water found no detected concentrations. Therefore, these five chemicals may be eliminated as COPCs in water due to their low detection frequency at this site.

Step 3: Comparison with Background Concentrations

Concentrations of analyzed metals in site soils were compared to their published background ranges (Dragun, 1988; Shacklette and Boerngen, 1984; ATSDR, 1997). This comparison is presented in Table 2-11. As shown, both the average and maximum concentrations of eight chemicals (aluminum, barium, beryllium, nickel, rubidium, strontium, vanadium, zirconium) fall squarely within the ranges reported for the United States. Therefore, these eight chemicals were eliminated from further analysis as COPCs at this site. The other chemicals were either clearly higher or not obviously within the reported background levels, and were carried further through the COPC selection process.

Step 4: Toxicity/Concentration Screen

The final step used to evaluate COPCs at this site was a toxicity/concentration screen conducted in accord with USEPA (1994) guidance. This step involves comparing the maximum reported concentration of a chemical in a medium to an appropriate Risk-Based Concentration (RBC). RBCs are media-specific health-based levels which if exceeded, could indicate that there is a potential for adverse health effects to occur as a result of exposure. If the maximum concentration value is less than the RBC, the chemical does not pose an unacceptable health risk and can be eliminated as a COPC. [Note: This is true providing that the chemical does not exceed any relevant ARAR values.]

The RBCs used in this evaluation were taken from USEPA's Region 3 Risk-Based Concentration (RBC) table for residential soil (USEPA 1999). The value of each RBC depends on the specified

Target Risk level. In accord with the goal that the COPC selection process should be conservative, the Target Risk levels used in this evaluation are 1E-06 for carcinogenic chemicals and a hazard quotient (HQ) of 0.1 for noncarcinogenic chemicals.

Table 2-12 lists the maximum concentration and RBC values used to evaluate each chemical in soil and water and identifies those chemicals which were not eliminated from further consideration at this step.

Summary

The following table summarizes the COPCs for soil and water selected for quantitative evaluation in the risk assessment at this site.

Chemical	Soil COPC	Tap Water COPC
Antimony	X	
Arsenic	X	X
Cadmium	X	X
Iron	X	
Lead	X	X
Manganese	X	
Mercury	X	
Silver	X	
Thallium	X	

For soils, with the exception of lead and iron, the ICP data sets will be used to evaluate risks from exposure to the COPCs identified at this site. As discussed previously, The XRF data sets for lead (data sets 1 and 2) and iron (data set 1) were judged to be adequate for use in risk assessment. Therefore, after adjustment of the data using the ICP/XRF regressions presented in Appendix A, the XRF data will be used for risk evaluation for these two chemicals.

3.0   EXPOSURE ASSESSMENT

Exposure is the process by which humans come into contact with chemicals in the environment. In general, humans can be exposed to chemicals in a variety of environmental media (e.g., soil, dust, water, air, food), and these exposures can occur through one or more of several pathways (ingestion, dermal contact, inhalation). Section 3.2 provides a discussion of possible pathways by which area residents and recreational users might come into contact with contaminants present in site media. Sections 4 and 5 describe the basic methods used to estimate the amount of chemical exposure (non-lead and lead) which humans may receive from direct and indirect contact with contaminants derived from outdoor soil.

3.1   Conceptual Site Model

Figure 3-1 presents a generalized conceptual site model showing the main pathways by which contaminants from current or former mining activities and other sources might come into contact with people who live or recreate within the Eureka Mills site boundary. Exposure scenarios that are considered most likely to be of concern are shown in Figure 3-1 by boxes containing a solid circle, while pathways which are judged to contribute only minor exposures are shown by boxes with a cross-hatched circle. Incomplete pathways (i.e., those which are not thought to occur) are shown by open circles.

3.1.1   Potential Sources

Soil contamination in and about the community of Eureka is a result of historic mining practices which occurred in the area. Numerous mine waste piles exist in close proximity to current residential areas.

3.1.2   Migration Pathways

The current medium of chief concern is soil. Metals in soil tend to have relatively low mobility and are most likely to move by wind-blown transport of suspended soil particles in air, surface run-off from nearby piles, or by hauling of bulk material from one location to another.

3.1.3   Exposed Populations and Potential Exposure Scenarios

There are a number of different groups or populations of humans who may come into contact with contaminants in area soils, including current residents, future residents and recreational visitors. The following text describes the scenarios which are considered plausible for each population, and identifies which are likely to be most important and which are sufficiently minor that they need not be evaluated quantitatively.

3.2   Pathway Screening

3.2.1   Residential Exposures

Incidental Ingestion of Soil/Dust

Few people intentionally ingest soil. However, it is believed that most people (especially children) do ingest small amounts of soil that adhere to the hands or other objects placed in the mouth. In addition, outdoor soil can enter the home and mix with indoor dust, which may also be ingested during meals or during hand-to-mouth activities. This exposure pathway is often one of the most important routes of human intake, so it was selected for quantitative evaluation.

There are three soil categories for which data exist at this site: surface, subsurface and earthen basement. Quantitative evaluation of soil risk was based on exposure to surface soils only. This was based on a review of the depth profile of soils at this site. Because the XRF data for non-lead COPCs was deemed inadequate, and due to the fact that sufficient paired data from the ICP confirmation set were unavailable, this judgement was based on the XRF data set for lead for which paired surface and subsurface data are available for 505 residential properties. Figure 3-2 shows the distribution of the ratio of lead concentrations in depth samples to those in surface samples. As shown, as depth increases, the concentration of lead in soils tends to decrease. Because insufficient data were available for the non-lead contaminants, this pattern was assumed to apply to all site COPCs. On this basis, it is concluded that contaminant levels in surface soils are likely to be higher than levels in subsurface soils. If subsurface soils were ever excavated and brought to the surface, risks would be similar to or less than those for surface soils.

Several properties at this site were identified as having earthen basements. Samples from 7 homes were collected and analyzed. Although it is possible that individuals residing in properties with earthen basements have intermittent contact with those soils, the concentrations of contaminants in basements are generally lower than those observed in outdoor soil. Therefore, exposure to basement soil was not evaluated separately.

Dermal Contact with Soil

Residents can get contaminated soil on their skin while working or playing in their yard. Even though information is limited on the rate and extent of dermal absorption of metals in soil across the skin, most scientists consider that this pathway is likely to be minor in comparison to the amount of exposure that occurs by soil and dust ingestion. This view is based on the following concepts: 1) most people do not have extensive and frequent direct contact with soil, 2) most metals tend to bind to soils, reducing the likelihood that they would dissociate from the soil and cross the skin, and 3) ionic species such as metals have a relatively low tendency to cross the skin even when contact does occur.   Screening calculations (presented in Appendix C) support the conclusion that dermal absorption of metals from dermal contact with soil is likely to be relatively minor compared to the

oral pathway, and omission of this pathway is not likely to lead to a substantial underestimate of exposure or risk. Based on these considerations, along with a lack of data to allow reliable estimation of dermal uptake of metals from soil, Region 8 generally recommends that dermal exposure to metals in soils not be evaluated quantitatively (USEPA 1995). Therefore, this pathway was not evaluated quantitatively in this risk assessment.

Inhalation of Soil/Dust in Air

Particles of contaminated soil or dust may become resuspended in air, and residents may breathe those particles both inside and outside their house. However, screening level calculations (presented in Appendix C) based on conservative estimates of soil release to air indicate that for residents, inhalation of particles is likely to be a small source of risk (less than 0.2%) compared to incidental ingestion of soil. Based on this, it was concluded that inhalation exposure is a sufficiently minor contributor to exposure and that it need not be included in the quantitative evaluation of residential exposure.

Ingestion of Home-Grown Vegetables

Area residents could be indirectly exposed to soil contaminants via consumption of vegetables grown in contaminated soil. Evaluation of this pathway can be conducted by use of site-specific data (i.e., measured concentrations of contaminants in locally-grown produce), or through use of mathematical models that predict uptake of a contaminant from soil into vegetables. No site-specific data are currently available for concentrations in local vegetables, so evaluation would require use of a mathematical model to estimate the concentration of COPCs which might occur in locally-grown vegetables. However, use of mathematical uptake models are generally quite uncertain and typically tend to overestimate actual uptake levels.

Although the use of simple mathematical models to predict uptake of metals into garden vegetables is thought to be highly inaccurate, often tending to over-predict risks due to their inability to account for non-linear uptake kinetics, a screening set of these calculations was performed for this site. Screening level calculations (presented in Appendix C) reveal that the summed non-cancer risks from ingestion of COPCs in garden vegetables are low (HI < 1) for both average and RME individuals. Additionally, cancer risks for both exposure assumptions were below 1E-04. It should be noted that these risks are likely to be higher than actual, due to limitations of the mathematical modeling.

The potential for low risk is supported by studies conducted at other sites within Utah. For example a 1995 study at the Kennecott Mining site found no significant uptake of lead and arsenic into fruit or leafy and root vegetables. Furthermore, the study concluded that "no substantial degree of either cancer or non-cancer risk due to arsenic or lead is expected to result from the consumption of garden vegetables". Additionally, a 1996 study at the Murray Smelter site concluded that the exposure to arsenic from leafy and root vegetables, legumes, and garden fruits was two orders of magnitude less than that from soil and indoor dust (URS 2001). However, due to gaps in our understanding of metal

uptake into garden vegetables specific to Eureka, a more reliable quantitative assessment pertaining to the magnitude of this overestimation can not be presented. Therefore, this pathway is not evaluated further in the risk assessment for this site.

Ingestion of Tap Water

The town of Eureka is supplied by a municipal water system, originating from wells located on the eastern flank of the Tintic Mountains. Some elevated levels of chemicals were found in tap water samples collected during the removal assessment. Because individuals at this site may be exposed to chemicals via ingestion of tap water at their residences, quantitative evaluation of this pathway was performed, even through the source of the metals in tap water is not thought to be site related. Although future residents may be exposed via this pathway, risks were calculated only for current residents based on the available data set.

3.2.2   Recreational Exposures

Certain individuals may be exposed to contaminated soils while participating in recreational activities at this site. Anecdotal reports have noted the presence of children and teenagers using the non-residential site areas for bike riding and general play activities. A survey of 31 youths (2 - 15 years) was conducted in order to assess how often the non-residential areas are used for recreational purposes. Of the respondents, only 2 children were found to frequent these areas for recreational activities, suggesting that this is a relatively uncommon activity that may apply to only a small subset of residents. However, because recreational activities were found to occur at this site, risks from recreational exposures were evaluated in this risk assessment. Individuals who engage in recreational activities may be exposed to contaminants by incidental ingestion, inhalation of particulates and/or dermal contact. Of these routes of exposure, ingestion exposure was assumed to be the most important and was evaluated in this report.

3.3   Summary of Pathways of Principal Concern

Based on the evaluations above, the following exposure scenarios are judged to be of sufficient potential concern to warrant quantitative exposure and risk analysis:

Exposure Scenarios of Potential Concern

Location	Population	Medium and Exposure Route
Residential Areas within Eureka	Current Residents	Incidental ingestion of soil and dust Ingestion of tap water
Non-Residential Areas	Hypothetical Future Residents	Incidental ingestion of soil and dust Ingestion of tap water
	Recreational Visitors	Incidental ingestion of soil and dust

4.0   QUANTIFICATION OF EXPOSURE AND RISK FROM NON-LEAD CONTAMINANTS

4.1   Quantification of Exposure

4.1.1   Basic Equation

The magnitude of human exposure to chemicals in an environmental medium is described in terms of the average daily intake (DI), which is the amount of chemical which comes into contact with the body by ingestion, inhalation, or dermal contact. The general equation for calculating the daily intake from contact with an environmental medium is (USEPA 1989a):

$$DI = C \times IR \times EF \times ED \times RBA / (BW \times AT)$$

where:

DI =   daily intake of chemical (mg/kg-d)
C   =   concentration of chemical in an environmental medium (e.g., mg/kg)
IR =   intake rate of the environmental medium (e.g., kg/day)
EF =   exposure frequency (days/yr)
ED =   exposure duration (years)
RBA= relative bioavailability of chemical in site medium
BW =   body weight (kg)
AT =   averaging time (days)

For mathematical and computational convenience, this equation is often written as:

$$DI = C \times HIF \times RBA$$

where:

HIF =   "Human Intake Factor". For soil and dust ingestion, the units of HIF are
kg/kg-day. The value of HIF is given by:

$$HIF = IR \times EF \times ED / (BW \times AT)$$

There is often wide variability in the amount of contact between different individuals within a population. Thus, human contact with an environmental media is best thought of as a distribution of possible values rather than a specific value. Usually, emphasis is placed on two different portions of this distribution:

- Average or Central Tendency Exposure (CTE) refers to individuals who have average or typical intake of environmental media.

- Upper Bound or Reasonable Maximum Exposure (RME) refers to people who are at the high end of the exposure distribution (approximately the 95th percentile). The RME scenario is intended to assess exposures that are higher than average, but are still within a realistic range of exposure.

4.1.2 Exposure Parameters

Soil and Dust Ingestion by Residents

Based on the assumption that the concentration of contaminants is approximately equal in outdoor yard soil and indoor house dust, the EPA usually evaluates residential exposure to soil and dust in a single step. The basic equation is as follows:

$$DI_{sd} = C_{sd} \cdot RBA \left(\frac{IR_{sd}}{BW} \right) \left(\frac{EF_{sd} \cdot ED}{AT} \right)$$

Both chronic and lifetime average intake rates are time-weighted to account for the possibility that an adult may begin exposure as a child (USEPA 1989a, 1991a, 1993), as follows:

$$TWA - DI_{sd} = C_{sd} \cdot RBA \left(\frac{IR_c}{BW_c} \cdot \frac{EF_c \cdot ED_c}{(AT_c + AT_a)} + \frac{IR_a}{BW_a} \cdot \frac{EF_a \cdot ED_a}{(AT_c + AT_a)} \right)$$

where:

TWA-DI$_{sd}$ = Time-weighted Daily Intake from ingestion of soil and dust (mg/kg-d)
C$_{sd}$ = Concentration of chemical in soil and dust (mg/kg)
RBA = relative bioavailability of chemical (unitless)
IR = Intake rate (kg/day) when a child (IR$_c$) or an adult (IR$_a$)
BW = Body weight (kg) when a child (BW$_c$) or an adult (BW$_a$)
EF = Exposure frequency (days/yr) when a child (EF$_c$) or an adult (EF$_a$)
ED = Exposure duration (years) when a child (ED$_c$) or an adult (ED$_a$)
AT = Averaging time (days) while a child (AT$_c$) or an adult ($_{Ata}$)

For mathematical and computational convenience, this equation can be rewritten as:

$$TWA-DI_{sd} = C_{sd} \cdot RBA \cdot HIF$$

where:

HIF = "Human Intake Factor". For soil and dust ingestion, the units of HIF are kg/kg-day. The value of HIF is given by:

$$HIF = \left(\frac{IR_c}{BW_c} \cdot \frac{EF_c \cdot ED_c}{(AT_c + AT_a)} + \frac{IR_a}{BW_a} \cdot \frac{EF_a \cdot ED_a}{(AT_c + AT_a)} \right)$$

Default values and assumptions recommended by USEPA (1989a, 1991a, 1993) for evaluation of residential exposure to soil and dust are listed below:

Exposure Parameter	CTE		RME	
	Child	Adult	Child	Adult
IR (kg/day)	1E-04	5E-05	2E-04	1E-04
BW (kg)	15	70	15	70
EF (days/yr)	234	234	350	350
ED (years)	2	7	6	24
AT (noncancer effects) (days)	2 x 365	7 x 365	6 x 365	24 x 365
AT (cancer effects) (days)	--	70 x 365	--	70 x 365

Both chronic and lifetime average intake rates are time-weighted to account for the possibility that an adult may begin exposure as a child. Based on the exposure parameters above, the HIFs for exposure of children and adults to soil and dust are as follows:

Residential Exposure to Soil plus Dust	HIF$_{sd}$ (kg/kg-d)	
	CTE	RME
TWA-chronic (non-cancer)	1.3E-06	3.7E-06
TWA-lifetime (cancer)	1.7E-07	1.6E-06

However, studies at several mining/milling/smelting sites have revealed that the concentration of metals is often not as high in indoor dust as in outdoor soil. In this situation, it is necessary and appropriate to evaluate exposure to soil and dust separately, as follows:

$$DI_{sd} = C_s \times RBA_s \times HIF_s + C_d \times RBA_d \times HIF_d$$

where:

C = Concentration in soil (C_s) or in dust (C_d)
RBA = Relative Bioavailability in soil (RBA_s) or in dust (RBA_d)
HIF = Human Intake Factor for soil (HIF_s) or dust (HIF_d)

If f_s is defined as the fraction of total intake that is soil, the HIF_s and HIF_d can be calculated by using the following equations:

$$HIF_s = f_s \times HIF_{sd}$$

$$HIF_d = (1-f_s) \times HIF_{sd}$$

Data are sparse on the relative amounts of soil and dust ingestion by residents, but limited data support the view that total intake is composed of about 45% soil and 55% dust in children (USEPA 1994). By extrapolation, this ratio is also assumed to apply to resident adults. Thus:

$$f_s = 0.45$$

Therefore, the resulting HIF_s and HIF_d values are shown in the following table.

Residential Exposure	HIF_s (kg/kg-d)		HIF_d (kg/kg-d)	
	Average	RME	Average	RME
TWA-chronic (non-cancer)	5.9E-07	1.6E-06	7.2E-07	2.0E-06
TWA-lifetime (cancer)	7.6E-08	7.1E-07	9.2E-08	8.6E-07

Water Ingestion by Residents

The basic equation for evaluation of exposure from groundwater ingestion is as follows:

$$DI_w = C_w \cdot RBA \left(\frac{IR_w}{BW} \right) \left(\frac{EF_w \cdot ED}{AT} \right)$$

where:

        DI_w = Average daily intake of chemical from drinking water (mg/kg-day)
        C_w = Concentration in drinking water (mg/L)
        RBA = Relative Bioavailability of chemical in water (unitless)
        IR_w = Intake rate of water (L/day)
        BW = Body weight (kg)
        EF_w = Exposure frequency to drinking water (days/yr)
        ED = Exposure duration (years)
        AT = Averaging time (days)

For mathematical and computational convenience, this equation can be rewritten as:

$$DI_w = C_w \cdot RBA \cdot HIF$$

where:

        HIF = "Human Intake Factor". For soil and dust ingestion, the units of HIF are
            kg/kg-day. The value of HIF is given by:

$$HIF = \left(\frac{IR_w}{BW} \right) \left(\frac{EF_w \cdot ED}{AT} \right)$$

Standard EPA defaults (USEPA 1989a, 1991a, 1993) for evaluation of water ingestion by residents are as follows:

Parameter	CTE		RME	
	Child	Adult	Child	Adult
IR (L/day)	0.7	1.4	1.0	2.0
BW (kg)	15	70	15	70
EF (days/yr)	234	234	350	350
ED (years)	2	7	6	24
AT (noncancer effects) (days)	2 x 365	9 x 365	6 x 365	30 x 365
AT (cancer effects) (days)	--	70 x 365	--	70 x 365

Based on these exposure parameters, the HIF values for exposure of residents to drinking water are as follows:

Residential Exposure to Drinking Water	HIF_w (L/kg-d)	
	CTE	RME
TWA-Chronic (non-cancer)	1.7E-02	3.5E-02
TWA-Lifetime (cancer)	2.1E-03	1.5E-02

Soil Ingestion by Recreational Visitors

As noted above, a small fraction of the population may be exposed to site contamination via recreational exposure. The small survey conducted at this site confirmed that exposure does occur, but the information collected does not allow for a reliable estimation of exposure frequency or soil intake rates at these areas. However, limited data regarding the frequency and duration for which children ride their bicycles in the residential areas of town. These data were applied to a recreational visitor as follows.

The following table summarizes the data obtained from the youth recreational activity survey in which parents were asked to identify how often their children rode their bicycles. Only children over 6 years of age who answered positively to riding bikes are included in this table.

Age (yrs)	Ride Activity	Frequency (rides/wk)	Ride Time	Duration (hours/ride)	Combined (hrs/week)
9	1	1.5	1	1.5	2.25
12	1	1.5	1	1.5	2.25
14	1	1.5	1	1.5	2.25
13	2	3.5	1	1.5	5.25
9	2	3.5	1	1.5	5.25
11	3	6	1	1.5	9
12	3	6	1	1.5	9
9	3	6	2	4.5	27
11	3	6	2	4.5	27
14	3	6	2	4.5	27
15	3	6	2	4.5	27
11	3	6	3	7	42
11	3	6	3	7	42
13	3	6	3	7	42

The survey response for children who ride bikes was placed into one of three "ride activity" categories:

> 1 =   1 or 2 times a week
> 2 =   3 or 4 times a week
> 3 =   5 or more times a week

In order to be used for estimating ride frequencies, these ride activity categories were assigned values of 1.5, 3.5 and 6 times a week, respectively.

The survey also tracked the average length of time ("ride time") a child rode his/her bike for each ride:

$$1 = \quad \text{1 or 2 hours}$$
$$2 = \quad \text{3 or 5 hours}$$
$$3 = \quad \text{6 or more hours}$$

These categories were also assigned a value in order to be used to estimate exposure parameters (shown in Duration Hours/Ride). The following values were assigned (1 = 1.5 hours; 2 = 4.5 hours; 3 = 7 hours).

The frequency value for each child was multiplied by the duration in order to obtain a value for each child equivalent to the number of hours of ride time each week. These values are shown in the above table under the heading "Combined hrs/week". Summary statistics were then obtained using this "combined information".

The following table summarizes the 50th and 95th percentile values for hours/week riding. These values were converted to hours per year by assuming that the riding year was 8 months long (32 weeks) in Eureka. This value was then divided by 365 days in order to obtain estimates of the average hours/day riding for both the 50th and 95th percentile of the respondents.

%tile	hrs/wk	hrs/yr*	hrs/day
50th	18	576	1.6
95th	42	1344	3.7

*Assumes that year is equivalent to 4 wks/month for 8 months

The values and assumptions used for evaluation of recreational exposure to soil are listed below:

Exposure Parameter	CTE	RME
IR (mg/hr)	25	50
BW (kg)	40	40
Time (hr/day)	1.6	3.7
EF (days/yr)	365	365
ED (years)	6	12
AT (noncancer effects) (days)	6 x 365	12 x 365
AT (cancer effects) (days)	70 x 365	70 x 365

The intake rate parameter was estimated using the default child soil ingestion rates of 100 mg/day and 200 mg/day for CTE and RME scenarios, respectively. If it was assumed that each recreational visit lasted 4 hours, the hourly rate of ingestion would be 25 mg/hr and 50 mg/hr for these two scenarios. It should be noted that the adult residential intake is based on a 16 hour day, therefore use of these values in the recreational exposure assumes an intake 4 times greater than that of an adult resident.

As described above, the estimation of hours/day spent riding was based on a year-long average. Therefore, the exposure frequency (EF) shown above is 365 days/yr. The exposure duration assumption was set at 6 and 12 years for CTE and RME exposure scenarios, respectively, based on a maximum possible exposure of 12 years for a target population ranging in age from 6 to 18 years.

Based on the exposure parameters above, the HIFs for exposure of teenagers to soil are as follows:

Recreational Exposure to Soil	HIF_s (kg/kg-d)	
	CTE	RME
Chronic (non-cancer)	1.00E-06	4.63E-06
Lifetime (cancer)	8.57E-08	7.93E-07

4.1.3   Concentration of Non-Lead COPCs (C)

Residential Surface Soil

The concentration term in the basic equation above (see Section 4.1.1) is the arithmetic mean concentration of a contaminant, averaged over the location (Exposure Point) where exposure is presumed to occur during a specified time interval (USEPA 1989a). The location and size of the Exposure Point depends in part on human activity patterns and in part on the length of time that is required for a chemical to cause adverse effects. In this case, arsenic is of concern for chronic (long-term) exposures, so the appropriate exposure unit is the area over which a resident is exposed over the course of many years. Based on this concept, the residential area was divided into 6 exposure areas as shown in Figure 2-2.

Because the true mean concentration of a chemical within an Exposure Area cannot be calculated with certainty from a limited set of measurements, the USEPA recommends that the upper 95th confidence limit (UCL) of the arithmetic mean concentration be used as the Exposure Point Concentration (EPC) in calculating exposure and risk (USEPA 1992). If the calculated UCL is higher than the highest measured value, then the maximum value is used as the EPC instead of the UCL (USEPA 1992).

In accord with this policy, EPCs were calculated using all surface soil results analyzed by ICP (except for iron, for which XRF was used) for each of the COPCs identified at this site. As discussed earlier, the XRF data were judged unreliable for use in risk assessment. Table 4-1 presents summary statistics for antimony, arsenic, cadmium, iron, manganese, mercury, silver and thallium stratified by exposure area. As shown, no surficial soil data by ICP were available for Area #6 , therefore risks at this area were not evaluated.

<u>Indoor Dust</u>

Current Residential Areas

The COPCs selected for evaluation in indoor dust were the same as those identified for soil (antimony, arsenic, cadmium, iron, manganese, mercury, silver and thallium). In some assessments, indoor dust concentrations are evaluated using a site-specific soil-dust regression model that predicts dust concentrations from yard soil concentrations. However, at this site, no suitable correlation between the COPCs in dust and their paired ICP soil data could be established. The lack of an observable correlation does not necessarily indicate that soil does not contribute to indoor dust concentrations. It is possible that the data set utilized for the analysis was too limited to establish a reliable relationship. Therefore, EPCs for the COPCs in dust within each exposure area were calculated using the measured data set for that area. Table 4-2 presents summary statistics for the dust COPCs stratified by exposure area. Because there were no dust data available for Exposure Area #3, the EPC value for dust obtained across the site (all) was assumed to apply to this area in order to evaluate potential risks to residents.

Future Residential Areas

Because no residential structures exist in the non-residential areas to be evaluated for future residential exposures, no data for indoor dust samples were available. Therefore, in order to assess risks to residents who may reside at these locations in the future, the concentration of indoor dust was estimated using the following equation.

$$C_d = k_s * C_s$$

where:

C_d	=	Concentration in indoor dust (mg/kg)
k_s	=	mass fraction of yard soil in indoor dust (unitless)
C_s	=	Concentration in yard soil (mg/kg)

Ideally, the value of k_s for each chemical would be based on a site-specific relationship between dust and soil at current residential properties. However, as discussed above, no reliable relationship was observed for the non-lead COPCs in these media. Therefore the site specific k_s observed for lead (0.15 - discussed

in Section 5.3.1) at this site was employed for all non-lead COPCs in order to assess future residential exposure from indoor dust.

Tap Water

Exposure Point Concentrations for arsenic and cadmium in water are provided in Table 4-3.

Non-Residential (Mine Waste) Surface Soil

As described in Section 2.1.1, soil samples were collected from 25 locations surrounding the Eureka area (Figure 2-3). Several of these areas were combined based primarily on geographic location in order to represent potential exposure areas for recreational activities. The following table summarizes the groupings which resulted in a total of 7 unique exposure areas.

Exposure Area	Combined Areas	Description
A	3, 4, 5	Godiva
B	6, 25	Proposed Housing Areas
C	1,2, 7, 8, 9	Chief Mill 2
D	10, 11, 12, 13	Chief Mill 1
E	14, 15, 16, 17	Snow Flake/Chief Mine 1
F	18, 19, 20, 21, 22, 24	Bullion/Gemini
G	23	Keystone Mill Drainage

Summary statistics and EPCs for these exposure areas are provided in Table 4-4. No surface soil data via ICP for non-lead chemicals were available at either area B or G, and the available XRF data were not considered reliable for risk assessment. Therefore, these areas were not evaluated.

4.1.4   Relative Bioavailability (RBA)

Accurate assessment of the human health risks resulting from oral exposure to metals requires knowledge of the amount of metal absorbed from the gastrointestinal tract into the body. This information is especially important for environmental media such as soil or mine wastes, because metals in these media may exist, at least in part, in a variety of poorly water soluble minerals, and may also exist inside particles of inert matrix such as rock or slag. These chemical and physical properties may tend to influence (usually decrease) the absorption (bioavailability) of the metals when ingested.

The preferred method for obtaining site-specific estimates of RBA of a metal in soil is to measure the gastrointestinal absorption in animals dosed with site soils compared to that for the metal dissolved in water. However, such tests are costly and take considerable time to perform, and no such animal data are available for any soil samples from this site. However, it is sometimes possible to estimate an appropriate RBA if absorption in animals has been measured in a soil sample that is similar to site soils. The definition of "similar" is judgmental, but is based on a general similarity in the nature and amount of different forms ("phases") in the samples.

As mentioned in Section 2.6, 17 soils from this site underwent physical-chemical characterization for arsenic and lead. For arsenic, the physical-chemical characteristics of site samples (highest As concentration sample #EM-11 and an average of phases across all samples) were compared with the characteristics of a number of samples from other sites for which arsenic absorption data are available from tests in animals. Based mainly on the pattern of principal phases, soils from the Eureka Mills site were judged to be most similar to two samples; a slag sample from the Murray Smelter site and a tailing sample from the Clark Fork River. A summary of phases seen in these samples is provided below.

Arsenic Phase	Relative Arsenic Mass (% Total)			
	Eureka EM-11 (highest As conc.)	Eureka (average all materials)	Murray Smelter Slag	CFR Grant Kohr's Tailing
Fe Oxide	38%	42.2%	26.6%	53.5%
PbAsO	44.6%	17.9%	48.8%	--
Fe Sulfate	12.3%	24.2%	9.9%	16.7%

As seen, although neither the Murray or Clark Fork River samples are identical in composition to the Eureka samples, several strong similarities exist. Both samples are similar to Eureka in their relative arsenic masses in the iron oxide and iron sulfate mineral phases. Murray Slag, although lower than Eureka for iron oxide, also contains similar levels of lead arsenic oxide. Due to these similarities, the RBAs established for both of these samples through *in vivo* testing in young swine were reviewed for application at this site. The Murray slag sample, when tested in juvenile swine was found to have a RBA factor of 0.63 for arsenic (WESTON, 1996a). The Clark Fork River Grant Kohr's tailing sample was found to have an RBA of 0.49 for arsenic (ISSI, 1998). Based on the similarities between the site soils and these samples, a factor of 0.55 was selected to apply to arsenic in soils from Eureka and was utilized in this risk assessment. This value is somewhat lower than the default value of 0.80 that is used to evaluate arsenic in soil when no other site-specific data are available.

Selection of this value is supported by results from *in vitro* bioaccessability testing performed on the site soils (Table 2-8). Bioaccessability tests measure the relative solubility of a chemical under specified laboratory test conditions. Thus, *in vitro* solubility may not necessarily be equal to the RBA *in vivo*. However, chemicals that are not readily dissolved from soil *in vitro* are also likely to be absorbed relatively slowly *in vivo*. Results of *in vitro* bioaccessability tests for arsenic in soil samples from the Eureka Mills

site had a tremendous amount of variability, with a range of 0.04 to 0.42 and an average value of 0.13 (excluding the result for EM-9 which was eliminated due to a low arsenic concentration). Due to the variability in this dataset, the range and average presented above may have little use in estimating the RBA. However, the *in vitro* data do support the view that arsenic in the soil is not all readily soluble and indicate that the RBA value of 0.55 selected for use at this site is likely to be reasonable.

Due to a lack of information regarding the bioavailability of the other COPCs, an RBA value of 1.0 was used for each of these chemicals. For water, all COPCs were evaluated using an RBA value of 1.0. The selection of an RBA value of 1.0 is protective because it assumes that 100% of the ingested chemicals are absorbed. Although these chemicals may, in fact, have absorption values of less than 100%, insufficient information is available to justify selection of a lower value.

4.2   Toxicity Assessment

The toxic effects of a chemical generally depend not only upon the inherent toxicity of the compounds and the level of exposure (dose), but also on the route of exposure (oral, inhalation, dermal) and the duration of exposure (subchronic, chronic or lifetime). Thus, a full description of the toxic effects of a chemical includes a listing of what adverse health effects the chemical may cause, and how the occurrence of these effects depend upon dose, route, and duration of exposure.

The toxicity assessment process is usually divided into two parts: the first characterizes and quantifies the non-cancer effects of the chemical, while the second addresses the cancer effects of the chemical. This two-part approach is employed because there are typically major differences in the time-course of action and the shape of the dose-response curve for cancer and non-cancer effects.

Non-Cancer Effects

Essentially all chemicals can cause adverse health effects if given at a high enough dose. However, when the dose is sufficiently low, typically no adverse effect is observed. Thus, in characterizing the non-cancer effects of a chemical, the key parameter is the threshold dose at which an adverse effect first becomes evident. Doses below the threshold are considered to be safe, while doses above the threshold are likely to cause an effect.

The threshold dose is typically estimated from toxicological data (derived from studies of humans and/or animals) by finding the highest dose that does not produce an observable adverse effect, and the lowest dose which does produce an effect. These are referred to as the "No-observed-adverse-effect-level" (NOAEL) and the "Lowest-observed-adverse-effect-level" (LOAEL), respectively. The threshold is presumed to lie in the interval between the NOAEL and the LOAEL. However, in order to be conservative (protective), non-cancer risk evaluations are not based directly on the threshold exposure level, but on a value referred to as the Reference Dose (RfD). The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

The RfD is derived from the NOAEL (or the LOAEL if a reliable NOAEL is not available) by dividing by an "uncertainty factor". If the data are from studies in humans, and if the observations are considered to be very reliable, the uncertainty factor may be as small as 1.0. However, the uncertainty factor is normally at least 10, and can be much higher if the data are limited. The effect of dividing the NOAEL or the LOAEL by an uncertainty factor is to ensure that the RfD is not higher than the threshold level for adverse effects. Thus, there is always a "margin of safety" built into an RfD, and doses equal to or less than the RfD are nearly certain to be without any risk of adverse effect. Doses higher than the RfD may carry some risk, but because of the margin of safety, a dose above the RfD does not mean that an effect will necessarily occur.

Cancer Effects

For cancer effects, the toxicity assessment process has two components. The first is a qualitative evaluation of the weight of evidence that the chemical does or does not cause cancer in humans. Typically, this evaluation is performed by the USEPA, using the system summarized in the table below:

Category	Meaning	Description
A	Known human carcinogen	Sufficient evidence of cancer in humans.
B1	Probable human carcinogen	Suggestive evidence of cancer incidence in humans.
B2	Probable human carcinogen	Sufficient evidence of cancer in animals, but lack of data or insufficient data from humans.
C	Possible human carcinogen	Suggestive evidence of carcinogenicity in animals.
D	Cannot be evaluated	No evidence or inadequate evidence of cancer in animals or humans.

For chemicals which are classified in Group A, B1, B2, or C, the second part of the toxicity assessment is to describe the carcinogenic potency of the chemical. This is done by quantifying how the number of cancers observed in exposed animals or humans increases as the dose increases. Typically, it is assumed that the dose response curve for cancer has no threshold, arising from the origin and increasing linearly until high doses are reached. Thus, the most convenient descriptor of cancer potency is the slope of the dose-response curve at low dose (where the slope is still linear). This is referred to as the Slope Factor (SF), which has dimensions of risk of cancer per unit dose.

Estimating the cancer Slope Factor is often complicated by the fact that observable increases in cancer incidence usually occur only at relatively high doses, frequently in the part of the dose-response curve that is no longer linear. Thus, it is necessary to use mathematical models to extrapolate from the observed high dose data to the desired (but unmeasurable) slope at low dose. In order to account for the uncertainty in this extrapolation process, USEPA typically chooses to employ the upper 95th confidence limit of the slope as the Slope Factor. That is, there is a 95% probability that the true

cancer potency is lower than the value chosen for the Slope Factor. This approach ensures that there is a margin of safety in cancer risk estimates.

The toxicity factors derived by the USEPA for oral exposure to the site COPCs are summarized below:

Chemical	Non-Cancer RfD (mg/kg-day)	Cancer	
		WOE	oral SF $(mg/kg-day)^{-1}$
Antimony	4E-04	--	--
Arsenic	3E-04	A	1.5
Cadmium	5E-04	B1*	--
Iron	3E-01	--	--
Manganese	1.4E-1	D	--
Mercury	3E-04	D	--
Silver	5E-3	D	--
Thallium	8E-05	D	--

* via inhalation

4.3   Risk Characterization

4.3.1   Overview

Risk characterization is the process of combining information on doses (Section 4.1) with toxicity information (Section 4.2) in order to estimate the nature and likelihood of adverse effects occurring in members of the exposed population. As explained earlier, this process is usually performed in two steps, the first addressing noncancer risks from chemicals of concern, and the second addressing cancer risks. The basic methods used to quantify noncancer and cancer risks are summarized below.

4.3.2   Noncancer Risk

Basic Equations

The potential for noncancer effects from exposure to a chemical is evaluated by comparing the estimated daily intake of the chemical over a specific time period with the RfD for that chemical derived for a similar exposed period. This comparison results in a noncancer Hazard Quotient, as follows (USEPA 1989a):

HQ = DI/RfD

where:

HQ = Hazard Quotient
DI   = Daily Intake (mg/kg-day)
RfD = Reference Dose (mg/kg-day)

If the HQ for a chemical is equal to or less than one (1E+00), it is believed that there is no appreciable risk that noncancer health effects will occur. If an HQ exceeds 1E+00, there is some possibility that noncancer effects may occur, although an HQ above 1E+00 does not indicate an effect will definitely occur. This is because of the margin of safety inherent in the derivation of all RfD values (see Section 3.6). However, the larger the HQ value, the more likely it is that an adverse effect may occur. If more than one chemical affects the same target tissue or organ system (e.g., the liver), then the total risk of adverse effects in that tissue is referred to as the Hazard Index (HI), and is estimated by summing the HQ values for all chemicals that act on that tissue.

4.3.3   Cancer Risk

Basic Equations

The risk of cancer from exposure to a chemical is described in terms of the probability that an exposed individual will develop cancer because of that exposure by age 70. For each chemical of concern, this value is calculated from the daily intake of the chemical from the site, averaged over a lifetime (DI_L), and the SF for the chemical, as follows (USEPA 1989a):

Cancer Risk = 1 - exp(-DI_L × SF)

In most cases (except when the product of DI_L*SF is larger than about 0.01), this equation may be accurately approximated by the following:

Cancer Risk = DI_L×SF

The level of cancer risk that is of concern is a matter of individual, community and regulatory judgement. However, the USEPA typically considers risks below 1E-06 to be so small as to be negligible, and risks above 1E-04 to be sufficiently large that some sort of action or intervention is usually needed (USEPA 1991b). Risks between 1E-04 and 1E-06 usually do not require action (USEPA 1991b), but this is evaluated on a case by case basis.

4.3.4   Results

The resulting risk estimates are shown in Tables 4-5 to 4-7.   Figures 4-1 to 4-3 show the sum (HI) of non-cancer (upper panel) and cancer (lower panel) risks for these areas. Table 4-5 provides the risk estimates for residential soil ingestion in exposure areas within the city of Eureka. As shown in this table and in Figure 4-1, summed risks for RME scenarios exceed a value of 1.0E+00 in areas 1, 2, 3, 4 and 5, with the majority of the risk attributable to arsenic and thallium.   However, contributions from each individual chemical did not exceed an HQ of 1.0E+00. Across the site as a whole (all areas) RME values exceed the 1.0E+00 level of concern, but average exposuresare below this level of concern.   With respect to excess cancer risk to residents, exposure to arsenic resulted in exceedances of a 1E-04 level of concern in exposure areas 3, 4, and 5 under RME exposure scenarios.

Table 4-6 shows risk estimates based on residential consumption of tap water. As seen, summed risks do not exceed a value of 1.0E+00 under either CTE or RME exposure assumptions. Excess cancer risk does not exceed a value of 1.0E-04, even under RME exposure assumptions.

Table 4-7 and Figures 4-2 through 4-3 present risks for exposure (recreational and future residential) at current non-residential areas. For recreational users, summed risks exceed a value of 1.0E+0 at all Exposure Areas sampled (A, C, D, E, and F) under both the RME exposure assumptions and the average exposure assumptions. As shown in Table 4-7, this elevated risk is primarily attributable to arsenic (HQ = 1.1). Excess risk is also attributable to antimony, mercury, and/or thallium in areas A, C, D, E, and F. Excess cancer risks were not found to exceed 1.0E-04 for recreational users at any of the non-residential exposure areas under the average exposure assumptions, but did exceed 1.0E-04 at Areas A, C, D, E, and F under the RME exposure assumptions.

The current non-residential areas were also evaluated for risks to potential future residents. As shown, chemicals in the majority of exposure areas (A-F) have summed non-cancer and cancer risks exceeding a level of concern. Risks in the majority of these areas are attributable to arsenic, however in a few instances (Areas A, C, and E), non-cancer risks from antimony and/or thallium also exceed an HQ of 1.0E+00. It is important to note that future residential development in the majority of these mine waste areas is unlikely without prior modification, as most of the land consists of large mine waste piles. An exception is Area B, which is currently proposed for residential development. However, risks at this location could not be evaluated since no ICP surface concentration data were available for this area.

4.4   Uncertainties

It is important to recognize that the exposure and risk calculations for the COPCs presented in this section are based on a number of assumptions, and that these assumptions introduce uncertainty into the dose and risk estimates. Assumptions are required because of data gaps in our understanding of the toxicity of chemicals, and in our ability to estimate the true level of human exposure to chemicals.

In most cases, assumptions employed in the risk assessment process to deal with uncertainties are intentionally conservative; that is, they are more likely to lead to an overestimate than an underestimate of risk. It is important for risk managers and the public to take these uncertainties into account when interpreting the risk conclusions derived for this site.

4.4.1   Uncertainties in Concentration Estimates

Evaluation of human health risk at any particular location requires accurate information on the average concentration level of a COPC at that location. However, concentration values may vary from sample to sample, so the USEPA recommends that the 95% upper confidence limit of the mean be used in evaluation of both average and RME exposure and risk. This approach typically ensures that all of the risk estimates are more likely to be high than low.

The data collected for use at this site was subject to a great deal of uncertainty surrounding true concentration values. Based on a review of data adequacy for soils, it was determined that the XRF data collected for non-lead COPCs (with the exception of iron) was not suitable for use in the risk assessment. Therefore, results for the subset of samples submitted for confirmation analysis by ICP was utilized. Although, ICP is considered to be reliable and accurate, these data represent only a subset of the site samples. Therefore, it is possible that some locations are not adequately represented in the risk assessment. In fact, some areas at this site could not be evaluated due to a lack of data.

Risks from exposure to non-lead COPCs were evaluated based on surficial soil data. As discussed in Section 3.2.1, this decision was based on the depth profile observed for lead, since data for the other analytes were insufficient to assess depth profiles. If the depth distribution for the non-lead COPCs does in fact mimic that observed for lead, risks from exposure to subsurface soils will be similar or less than those observed for surface soils. However, if concentrations for these analytes are found to increase as a function of depth, the risks based on surface soil exposure will underestimate risks for exposure to buried materials.

For dust, the future residential areas were evaluated using a k_s value of 0.15, based on the k_s value for lead observed at this site. Although the true k_s value for any given chemical at Eureka may fall between a range of 0 - 1.0, it is more likely to fall on the lower end of this range. This is supported by the lack of an observable soil-dust relationship in the current site data.

4.4.2   Uncertainties in Human Intake

As discussed in Section 3.2, there is usually wide variation between different individuals with respect to the level of contact they may have to chemicals in the environment. This introduces uncertainty into the most appropriate values to use for exposure parameters such as soil and dust intake rates, number of years at the residence, etc. Because of the uncertainty in the most appropriate values for these parameters, the USEPA generally recommends default values that are more likely to overestimate than underestimate exposure and risk.

4.4.3   Uncertainties in Toxicity Values

One of the most important sources of uncertainty in a risk assessment is in the RfD values used to evaluate noncancer risk and in the slope factors used to quantify cancer risk. In many cases, these values are derived from a limited toxicity database, and this can result in substantial uncertainty, both quantitatively and qualitatively. For example, there is continuing scientific debate on the accuracy of the oral slope factor and the oral Reference Dose for arsenic and whether or not they are accurate and appropriate for predicting hazards from relatively low dose exposures. In order to account for these and other uncertainties associated with the evaluation of toxicity data, both RfDs and SFs are derived by the USEPA in a way that is intentionally conservative; that is, risk estimates based on these RfDs and SFs are more likely to be high than low.

4.4.4   Uncertainties in Absorption from Soil

Another important source of uncertainty regarding the toxicity of arsenic is the degree to which it is absorbed into the body after ingestion of soil. Toxicity factors (RfD, oSF) for arsenic are based on observed dose response relationships when exposure occurs by ingestion of arsenic dissolved in water. If arsenic in soil is not absorbed as well as arsenic in water, use of unadjusted toxicity factors will tend to overestimate risk. At this site, a relative bioavailability factor for arsenic of 0.55 was estimated based on data from samples tested in juvenile swine that appeared to be similar in metal-phase composition. However, use of this factor is uncertain because of possible differences between the samples. Results of in vitro bioaccessability testing on site materials, which showed an average value of 0.13, supported the use of a value less than the USEPA default of 0.80 for arsenic in soil. However, this value was over three-fold lower than the value used in the risk assessment, indicating that the true risk from arsenic at this site may be lower than estimated. If the true RBA of arsenic in soil were 0.13, all of the risks presented in this assessment would be reduced by a factor of 0.55/0.13.

Based on this adjustment, current residential risks from arsenic would not exceed an HQ of 1E+00 or a risk level of 1E-04 at any area. Additionally, risks to recreational users in mine waste areas would not exceed an HQ of 1E+00 or a risk level of 1E-04 at any area. Excess non-cancer risks under a future residential scenario at the mine waste areas would be seen for average individuals at Area E (HI = 2E+00) and for RME individuals at all areas evaluated (HI = 2E+00 to 5E+00). A review of these non-cancer risks shows that the majority of this excess risk is attributable to arsenic, antimony and/or thallium.   Excess cancer risks (~2E-04) for hypothetical future residents from exposure to arsenic were observed at Areas D, E and F, based on the adjustment in RBA.

4.4.5   Uncertainties from Pathways Not Evaluated

As discussed in Section 3, not all possible pathways of human exposure to site COPCs were evaluated quantitatively in this risk assessment, and omission of these pathways presumably leads to some degree of underestimation of total risk. For some of these pathways (inhalation of airborne dust, dermal absorption from soil on the skin), the underestimation of risk is believed to be minimal (see Appendix C). In the case

of ingestion from home-grown garden vegetables, the magnitude of the underestimation is less certain. Studies at other sites (Sverdrup, 1995) suggest that exposure by this pathways is probably not as large as by oral exposure, but that the contribution is not completely negligible. Screening level calculations (presented in Appendix C) reveal that the non-cancer risk from ingestion of COPCs in garden vegetables is low (HI < 1) for both average and RME individuals. As mentioned above, these estimated risks are likely to be higher than actual, due to limitations of the mathematical modelling. However, the magnitude of this risk contributed by pathway is expected to vary widely from site to site, depending on the amount of uptake from soil into plants and the amount and type of produce actually grown and consumed by area residents.

5.0   RISKS FROM LEAD

As noted earlier, risks from lead are evaluated using a somewhat different approach than for most other metals. First, because lead is widespread in the environment, exposure can occur by many different pathways. Thus, lead risks are usually based on consideration of total exposure (all pathways) rather than just to site-related exposures. Second, because studies of lead exposures and resultant health effects in humans have traditionally been described in terms of blood lead level (PbB, expressed in units of ug/dL), lead exposures and risks are typically assessed using an uptake-biokinetic model rather than an RfD approach. Therefore, calculating the level of exposure and risk from lead in soil also requires assumptions about the level of lead in other media, and also requires use of pharmacokinetic parameters and assumptions that are not needed in traditional methods.

For residential land use, the sub-population of chief concern is young children. This is because young children 1) tend to have higher exposures to lead in soil, dust and paint, 2) tend to have a higher absorption fraction for ingested lead, and 3) are more sensitive to the toxic effects of lead than are older children or adults. For non-residential exposures (e.g., recreation, occupational) the population of chief concern are older children and young adults. When adults are exposed, the sub-population of chief concern is pregnant women and women of child-bearing age, since the blood lead level of a fetus is nearly equal to the blood lead level of the mother (Goyer 1990).

5.1   Adverse Effects of Lead Exposure

Excess exposure to lead can result in a wide variety of adverse effects in humans. Chronic low-level exposure is usually of greater concern for young children than older children or adults. There are several reasons for this focus on young children, including the following: 1) young children typically have higher exposures to lead-contaminated media per unit body weight than adults, 2) young children typically have higher lead absorption rates than adults, and 3) young children are more susceptible to effects of lead than are adults. The following sections summarize the most characteristic and significant of the adverse effects of lead on children, and current guidelines for classifying exposures as acceptable or unacceptable.

5.1.1   Neurological Effects

The effect of lead that is usually considered to be of greatest concern in children is impairment of the nervous system. Many studies have shown that animals and humans are most sensitive to the effects of lead during the time of nervous system development, and because of this, the fetus, infants and young children (0-6 years of age) are particularly vulnerable. The effects of chronic low-level exposure on the nervous system are subtle, and normally cannot be detected in individuals, but only in studies of groups of children. Common measurement endpoints include various types of tests of intelligence, attention span, hand-eye coordination, etc. Most studies observe effects in such tests at blood lead levels of 20-30 ug/dL, and some report effects at levels as low as 10 : g/dL and even lower. Such effects on the nervous system are long-lasting and may be permanent.

5.1.2   Effects on Pregnancy and Fetal Development

Studies in animals reveal that high blood lead levels during pregnancy can cause fetotoxic and teratogenic effects. Some epidemiologic studies in humans have detected an association between elevated blood lead levels and endpoints such as decreased fetal size or weight, shortened gestation period, decreased birth weight, congenital abnormalities, spontaneous abortion and stillbirth (USEPA 1986). However, these effects are not detected consistently in different studies, and some researchers have detected no significant association between blood lead levels and signs of fetotoxicity. On balance, these data provide suggestive evidence that blood lead levels in the range of 10-15 ug/dL may cause small increases in the risk of undesirable prenatal as well as postnatal effects, but the evidence is not definitive.

5.1.3   Effects on Heme Synthesis

A characteristic effect of chronic high lead exposure is anemia stemming from lead-induced inhibition of heme synthesis and a decrease in red blood cell life span. ACGIH (1995) concluded that decreases in ALA-D activity (a key early enzyme involved in heme synthesis) can be detected at blood lead levels below 10 ug/dL. Heme synthesis is inhibited not only in red blood cells but in other tissues. Several key enzymes that contain heme, including those needed to form vitamin D, also show decreased activity following lead exposure (USEPA 1986). The CDC (1991) reviewed studies on the synthesis of an active metabolite of vitamin D and found that impairment was detectable at blood lead levels of 10 - 15 ug/dL.

5.1.4   Cancer Effects

Studies in animals indicate that chronic oral exposure to very high doses of lead salts may cause an increased frequency of tumors of the kidney (USEPA 1989b, ACGIH 1995). However, there is only limited evidence suggesting that lead may be carcinogenic in humans, and the noncarcinogenic effects on the nervous system are usually considered to be the most important and sensitive endpoints of lead toxicity (USEPA 1988). ACGIH (1995) states that there is insufficient evidence to classify lead as a human carcinogen.

5.1.5   Current Guidelines for Protecting Children from Lead

It is currently difficult to identify what degree of lead exposure, if any, can be considered safe for infants and children. As discussed above, some studies report subtle signs of lead-induced effects in children and perhaps adults beginning at around 10 ug/dL or even lower, with population effects becoming clearer and more definite in the range of 30-40 ug/dL. Of special concern are the claims by some researchers that effects of lead on neurobehavioral performance, heme synthesis, and fetal development may not have a threshold value, and that the effects are long-lasting (USEPA 1986). On the other hand, some researchers and clinicians believe the effects that occur in children at low blood lead levels are so minor that they need not be cause for concern.

After a thorough review of all the data, the USEPA identified 10 ug/dL as the concentration level at which effects begin to occur that warrant avoidance, and has set as a goal that there should be no more than a 5% chance that a child will have a blood lead value above 10 ug/dL (USEPA 1991b). Likewise, the Centers for Disease Control (CDC) has established a guideline of 10 ug/dL in preschool children which is believed to prevent or minimize lead-associated cognitive deficits (CDC 1991).

5.2   Methods for Assessing Lead Risks in a Community

The health risks which lead poses to a residential population can often be investigated in two different ways:

- Direct measurement of blood lead values in members of the population of concern.

- Measurement of lead in environmental media, and calculation of the range of risks those levels of lead could pose to individuals or populations.

As discussed below, each of these approaches has some advantages and some limitations, and the best assessment of lead risks incorporates the results of both types of approaches.

5.2.1   Blood Lead Monitoring

One way to investigate human health risks from lead in the environment is to measure the concentration of lead in the blood (PbB) in randomly-selected members of the population of concern. Such data allow comparison of site statistics (mean blood lead, percent of the population above 10 ug/dL, etc.) with corresponding national average statistics, in order to obtain a general sense of how much impact site contamination may have caused in the population. Further, the site statistics can be compared with health-based objectives and guidelines in order to determine if population-based health goals are being exceeded. In addition, blood lead studies which include reliable data on lead levels in various environmental media (soil, dust, paint, water, food) and which obtain reliable demographics data (age, sex, race, mouthing frequency, dietary status, etc.) can provide valuable insights into the media and exposure pathways that are the primary sources of concern in a population. For example, an analysis of the relationship between blood lead and lead levels in soil can help reveal how important soil is as a source of blood lead. However, there are some important limitations to the use of blood lead measurements as the only index of lead risk. First, care must be taken to ensure that a sufficient number of people are studied, and that these people are a representative subset of the population of concern. Second, blood lead values in an individual may vary as a function of time, so a single measurement may not be representative of the long-term average value in that individual. Third, because of the variability between people in contact rates for various media, it is expected that blood lead values will differ (either lower or higher) between individuals, even when they are exposed under the same environmental conditions. Thus, a blood lead level that is below a level of concern in one child living at a specific residence does not necessarily mean that some other child who might be exposed at the same location might not have a higher (and possibly unacceptable) blood lead level. Fourth, population-based studies are not well-suited for detecting the occurrence of

occasional sub-locations where risk is elevated, even if average risks are not above a level of concern. Finally, blood lead measurements reflect exposures and risks under current site conditions and population characteristics, which may not always be representative of past or future site conditions. For these reasons, results from blood lead studies may not provide a complete description of the range of risks which different members of a population might experience.

5.2.2   Modeling Approaches

Because of the limitations in the direct measurement approach, it is often useful to employ mathematical models as well as empirical methods for evaluation of lead risk. These models can then be used to assess the risks from lead under conditions which cannot be measured (e.g., risks to hypothetical future people in areas where there are no current exposures), to identify which exposure pathways are likely to be contributing the largest risk to a population, and to evaluate the likely efficacy of various remedial alternatives.

The standard model developed by the USEPA to assess the risks of lead exposure in residential children is referred to as the Integrated Exposure Uptake and Biokinetic (IEUBK) model. This model requires as input data on the levels of lead in various environmental media at a specific location, and on the amount of these media contacted by a child living at that location. The inputs to the IEUBK model are selected to reflect estimates of central tendency values (i.e., arithmetic means or medians). These estimated inputs are used to calculate an estimate of the central tendency (the geometric mean) of the distribution of blood lead values that might occur in a population of children exposed to the specified conditions. Assuming the distribution is lognormal, and given (as input) an estimate of the variability between different children (this is specified by the geometric standard deviation or GSD), the model calculates the expected distribution of blood lead values, and estimates the probability that any random child might have a blood lead value over 10 ug/dL.

USEPA Region 8 has been working to develop a variation of the IEUBK model in which variability in exposure between people and between locations is accounted for by using Probability Density Functions (PDFs) to specify inputs (rather than point estimates). This probabilistic model is referred to as the Integrated Stochastic Exposure (ISE) model for lead (SRC 1999). Because the model has not undergone a full peer review or validation, it is considered to be only an investigative tool. Nevertheless, the ISE model does offer an alternative means of assessing exposure and risk from lead at the site, as discussed in the uncertainty section of this chapter.

Limitations to Modeling

All predictive models, including the IEUBK model and the ISE model, are subject to a number of limitations. First, there is inherent difficulty in providing the models with reliable estimates of human exposure to lead-contaminated media. For example, exposure to soil and dust is difficult to quantify because human intake of these media is likely to be highly variable, and it is very difficult to derive accurate measurements of actual intake rates. Second, it is often difficult to obtain reliable estimates of key

pharmacokinetic parameters in humans (e.g., absorption fraction, distribution and clearance rates), since direct observations in humans are limited. Finally, the absorption, distribution and clearance of lead in the human body is an extremely complicated process, and any mathematical model intended to simulate the actual processes is likely to be an over-simplification. Consequently, model calculations and predictions are generally rather uncertain.

5.2.3   Weight-of-Evidence Evaluation

As the discussions above make clear, there are advantages and limitations to both the direct blood measurement approach and the predictive (mathematical modeling) approach. Therefore, when data are available to perform both types of analysis, the most appropriate means for evaluating risks from lead is to weigh the results of both analyses, taking into account the uncertainties and limitations of each. Final conclusions regarding current and future risk should thus be based on a balanced assessment of information from all sources.

5.3   Modeling of Lead Risk

5.3.1   Evaluation of Lead Risks to Current and Future Residents

The IEUBK model is recommended by the USEPA for use in the evaluation of risks from lead exposure in children on a property-by-property basis. A detailed printout of the input values used to evaluate lead risks at each property is presented in Appendix D. The following sections summarize the input parameters used for these calculations.

Lead Concentration in Soil

The XRF data sets (Data set #1 and #2) were used to evaluate risks from lead in surface soils. Prior to use, these data sets required adjustment to account for the discrepancy between reported XRF and ICP analyses. Based on the best-fit linear regression for the combined data sets (Figure 5-1), the following equation was used to adjust the data.

$$\text{Adj[Pb]} = 1.49 * \text{XRF[Pb]} \qquad (R^2 = 0.942)$$

Lead concentrations in yard soils were evaluated by calculating the average surface soil concentration at each unique residential property using the adjusted lead data set. A total of 505 properties were evaluated. In addition to the current residential properties, lead concentrations at 25 non-residential properties (see Figure 2-3) were evaluated for risks to hypothetical future children residing in these areas. Lead concentrations averaged at each of these mine waste properties are summarized in Table 5-1.

Lead Concentration in Indoor Dust

Concentrations of lead in dust at a property can be estimated from the measured level of lead in soil at the property using a site-specific soil-dust relationship. To obtain this relationship, the average soil concentration (based on the adjusted XRF data) for a property was plotted against the average dust concentration (measured by ICP) at that same property fit to an equation of the format:

$$C_d = slope*C_s + intercept$$

Where:

C_d = Average Concentration in Dust (mg/kg)
C_s = Average Concentration in Soil (mg/kg)

Figure 5-2 presents the site-specific soil-dust relationship for lead at this site, as described by the following equation:

$$C_d = 0.15*C_s + 458 \quad (R^2 = 0.229)$$

This relationship was also assumed to apply to evaluation of the current non-residential areas for future residential exposures. According to this equation, approximately 458 milligrams of lead per kilogram of indoor dust is coming from sources other than the yard. This indicates that an additional source of lead (e.g., paint) at these residences could be contributing significantly to indoor lead concentrations. However, due to the relatively poor fit ($R^2 = 0.229$) of the soil/dust relationship, the true intercept of this regression is uncertain.

Water and Air

For this analysis, lead concentrations in water at each property were assigned a value of 2.8 ug/L. This is equivalent to the average lead concentration measured in tap water at this site. Lead values for air were kept at the IEUBK default value of 0.1 ug/m^3.

Diet

The default values of lead intake from the diet in the IEUBK model are based on dietary data from 1982 - 1988. Recent FDA data provide strong evidence that concentrations of lead in food have continued to decline since 1988. Based on interpretations of the data, and an extrapolation from the downward trend observed in the 1980's, it has been estimated that the average lead intake from food by children has declined by approximately 30% (Griffin et al., 1999b). Therefore the dietary values were obtained by multiplying the model default values by a factor of 0.70. The resulting values are presented below:

Age (years)	Adjusted Dietary Intake (ug/day)
0-1	3.87
1-2	4.05
2-3	4.54
3-4	4.37
4-5	4.21
5-6	4.44
6-7	4.90

Age

Blood lead values for a child 50 months of age provide the best estimate of the long-term average blood lead predicted for months 6 to 84, therefore, predicted blood lead values were calculated at each property for a child 50 months of age. When using the model to assess measured versus predicted blood leads from the biomonitoring study, the actual age of the child at the time of participation was input into the model.

Absorption Fraction for Lead in Soil

The absorption fraction is a measure of the amount of metal absorbed from the gastrointestinal tract into the body. This information is especially important for environmental media such as soil or mine wastes, because metals in these media may exist, at least in part, in a variety of poorly water soluble minerals, and may also exist inside particles of inert matrix such as rock or slag. These chemical and physical properties may tend to influence (usually decrease) the absorption (bioavailability) of the metals when ingested.

As discussed above, the preferred method for obtaining absorption data on lead in soil or other mine wastes is through tests in animals. However, no such *in vivo* data for lead absorption are available for soils from this site. However, it is sometimes possible to estimate availability values in a soil by extrapolation from other similar soils that have been tested in animals. In order to judge which soil is the most appropriate basis for extrapolation, it is necessary to compare information on the chemical and physical characteristics of lead in the site soils with those in the soils that have been tested in animals.

The characteristics of lead-bearing particles in 17 soil samples from the site were characterized as described in Section 2.5. These samples had lead concentrations ranging from 551 to 23,604 mg/kg. The physical-chemical characteristics of the site samples were then compared with the characteristics of a number of samples from other sites for which lead absorption data are available from tests in animals (Table 5-2). Based mainly on the pattern of principal phases, soils from the Eureka Mills site were judged to be most similar to three samples: Aspen Residential, Aspen Berm and Jasper County Low Lead Yard.

Lead Phase	Relative Lead Mass (% Total)				
	Eureka EM-16 (highest Pb conc.)	Eureka (average all materials)	Aspen Residential	Aspen Berm	Jasper Low Lead Yard
Cerussite	90.6%	72.2%	64%	62%	81%
Fe Oxide	4.2%	7.3%	7%	9%	1%
Mn Oxide	4.8%	7.3%	5%	4%	2%
RBA	--	--	**0.61**	**0.60**	**0.80**

The Aspen Residential sample, when tested in young swine was found to have a relative bioavailability (RBA) factor of 0.61 for lead (Weston, 1996b). The Aspen Berm sample was found to have an RBA of 0.60 for lead (Weston, 1996b) and the Jasper County Low Lead Yard sample was found to have an RBA of 0.80 for lead (Weston, 1996c). Based on the similarities between the Eureka site soils and these samples (RBA range: 0.60 to 0.80), a factor of 0.70 was selected to apply to soils from Eureka and was utilized in this risk assessment. This value is somewhat higher than the default value of 0.60 that is used to evaluate lead in soil when no other site-specific data are available.

Use of this value is supported by results from *in vitro* bioaccessability testing performed on the site soils (Table 2-9). Bioaccessability tests are designed to measure the relative solubility of a chemical under specified laboratory test conditions. Thus, *in vitro* solubility may not be equal to the RBA *in vivo*. However, preliminary studies comparing these two methods have shown that the results are well-correlated.

Results of *in vitro* bioaccessability tests for soil samples from the Eureka Mills site ranged from 0.60 to 0.89, with an average value of 0.71. Thus, even though the *in vitro* bioaccessability values are not necessarily equivalent to *in vivo* RBA values, the *in vitro* data support the view that lead in the soil may be more soluble than default assumptions and indicate that the RBA value of 0.70 selected for use at this site is likely to be reasonable.

GSD

The GSD recommended as the default for the IEUBK model is 1.6 (USEPA 1994). However, several blood lead studies that have been performed in the Salt Lake City area have yielded GSD estimates of about 1.4 (Griffin et al., 1999b). Therefore, values of both 1.6 and 1.4 were evaluated in this assessment.

Other Model Inputs

Default parameters for the IEUBK model were retained for all other model inputs used in this analysis.

Results - Current Residential Risk Evaluation

The IEUBK model was used to evaluate the distribution of blood lead values that would be expected in a population of children living at a specific location, in order to judge whether the risks to any random child living at that location are within health based goals. This model was run for each residence within Eureka for which environmental data were collected (N=505) to estimate a predicted geometric mean (GM) blood lead level and the probability of exceeding a blood lead value of 10 ug/dL. For convenience, the probability of exceeding 10 ug/dL is referred to as "P10".

The results are shown in Figure 5-3, and summary statistics are presented in Table 5-3. Inspection of Figure 5-3 (upper panel) reveals that GM values are predicted to range from 5.1 to 47 ug/dL, with relatively little difference observed across exposure areas. Based on a GSD of 1.6 (default), PbB_{95} values (95th Percentile Blood Lead) (middle panel) are predicted to range from 11 to 101 ug/dL, with a community wide average of 33 ug/dL. Based on this, 100% of all properties are above EPA's health-based goal (P10 < 5%), and the predicted incidence of children with blood lead levels greater than 10 ug/dL is 69%. Even if a lower GSD of 1.4 is assumed (lower panel), the risks of elevated blood lead levels still exceed EPA's target at most properties, with a predicted incidence of 99%. These results indicate that risk to children from lead is likely to be well above EPA's health-based goal in nearly all locations at this site.

Results - Future Residential Risk Evaluation

Using the average soil lead concentrations presented in Table 5-1, the IEUBK model was run to determine predicted geometric mean blood lead levels for future residential children who might reside at one of the non-residential areas. Findings for this evaluation are presented in Table 5-4. Across all areas, the average predicted geometric mean blood lead concentration was 33.4 ug/dL (range 6 - 81.5 ug/dL). Regardless of the GSD used (1.4 or 1.6), all properties (100%) were found to have P10 values exceeding 5%, including those areas targeted for potential future development (Areas 6 & 25). Using a GSD of 1.6, these P10 values ranged from 16% to 100% (average 91%), whereas with a GSD of 1.4 a range of 8% to 100% (average 92%) was observed.

5.3.2   Evaluation of Lead Risks to Recreational Teenagers

The IEUBK model developed by EPA is intended for evaluation of lead risks to residential children, and is not appropriate for evaluation of lead risks to older children or adults exposed during recreational activities. However, there are several mathematical models which have been proposed for evaluating lead exposure in adults, including those developed by Bowers et al. (1994), O'Flaherty (1993), Leggett (1993), and the State of California (CEPA 1992). Of these, the biokinetic slope factor approach described by Bowers et al. has been identified by EPA's Technical Workgroup for Lead (USEPA 1996) as a reasonable interim methodology for assessing risks to adults from exposure to lead and for establishing risk-based concentration goals that will protect older children and adults from lead. For this reason, this method was used for estimating soil lead and tailings lead levels that could be of concern to older children and adults at this site.

Basic Equation

The Bowers model predicts the blood lead level in an adult exposed to lead in a specified occupational setting by summing the "baseline" blood lead level (PbB_0) (that which would occur in the absence of any above-average site-related exposures) with the increment in blood lead that is expected as a result of increased exposure due to contact with a lead-contaminated site medium. The latter is estimated by multiplying the absorbed dose of lead from site-related exposure by a "biokinetic slope factor" (BKSF). Thus, the basic equation is:

$$PbB = PbB_0 + (PbS \times BKSF \times IR_s \times AF_s \times EF_s)/AT$$

where:

PbB = Central estimate of blood lead concentrations (ug/dL) in adults (i.e., women of child-bearing age) that have site exposures to soil lead at concentration, PbS.

PbB_0 = Typical blood lead concentration (ug/dL) in adults (i.e., women of child-bearing age) in the absence of exposures to the site that is being assessed.

$BKSF$ = Biokinetic slope factor relating (quasi-steady state) increase in typical adult blood lead concentration to average daily lead uptake (ug/dL blood lead increase per ug/day lead uptake)

PbS = Soil lead concentration (ug/g) (appropriate average concentration for individual)

IR_s = Intake rate of soil, including both outdoor soil and indoor soil-derived dust (g/day)

AF_s = Absolute gastrointestinal absorption fraction for ingested lead in soil and lead in dust derived from soil (dimensionless). The value of AF_s is given by:

$$AF_s = AF(food) * RBA(soil)$$

EF_s = Exposure frequency for contact with assessed soils and/or dust derived in part from these soils (days of exposure during the averaging period)

AT = Averaging time; the total period during which soil contact may occur; 365 days/year for continuing long term exposures.

Once the geometric mean blood lead value is calculated, the full distribution of likely blood lead values in the population of exposed people can then be estimated by assuming the distribution is lognormal with some specified geometric standard deviation (GSD). Specifically, the 95th percentile of the predicted distribution is given by the following equation (Aitchison and Brown 1957):

$$95th = GM \times GSD^{1.645}$$

Input values selected for each of these parameters are summarized below:

Parameter	Value	Source
PbB_0 (ug/dL)	2.1	USEPA (1996) and Based on mean of age 6-11 and age 12-19 years (Brody et al. 1994)
PbS (ppm)	varied	Table 5-1
BKSF (ug/dL per ug/day)	0.4	USEPA (1996)
IR (g/day exposed)	0.04	Based on intake rate of 25 mg/hr and an average of 1.6 hours exposed per day. Multiplied by a factor of 1E-03 g/mg.
EF_s (days exposed/yr)	365	Based on exposure assumptions discussed in Section 4 for CTE recreational visitors
AT (days)	365	USEPA (1996)
AF_o (unitless)	0.14	Based on an absorption factor for soluble lead of 0.20 (USEPA 1996) and a relative bioavailability of 0.7
GSD	1.8	Based on homogenous population (USEPA 1996)

Results

Based on these input parameters, the predicted geometric mean blood leads and PbB_{95}'s for recreational visitors exposed at different locations are summarized in Table 5-5. As seen, predicted geometric mean blood lead concentrations range from 2.8 to 98 ug/dL (average 24.5 ug/dL) and PbB_{95}s range from 7 to 259 ug/dL (average 64 ug/dL).

The USEPA has not yet issued formal guidance on the blood lead level that is considered appropriate for protecting the health of pregnant women or other adults. However, as noted above, EPA recommends that there should be no more than a 5% likelihood that a young child should have a PbB value greater than 10 ug/dL (EPA 1991b). This same blood lead level (10 ug/dL) is also taken to be the appropriate goal for

blood lead levels in the fetus, and hence in pregnant women and women of child-bearing age. Therefore, the health criterion selected for use in this evaluation is that there should be no more than a 5% chance that the blood level of a fetus will be above 10 ug/dL. This health goal is equivalent to specifying that the 95th percentile of the PbB distribution in fetuses does not exceed 10 ug/dL:

$$PbB_{95} fetal \# 10 \ ug/dL$$

The relationship between fetal and maternal blood lead concentration has been investigated in a number of studies. Goyer (1990) reviewed a number of these studies, and concluded that there was no significant placental/fetal barrier for lead, with fetal blood lead values being equal to or just slightly less than maternal blood lead values. The mean ratio of fetal PbB to maternal PbB in three recent studies cited by Goyer was 0.90. Based on this, the 95th percentile PbB in the mother is then:

$$PbB_{95} maternal = 10/0.90 = 11.1 \ ug/dL.$$

That is, the target blood lead level for pregnant women is estimated to be 11.1 ug/dL. Even though individuals in the recreational population are assumed to be mainly age 9-15, it is possible that women of child-bearing age may also be included in this group, so the same target blood lead value is assumed to apply to this population as well.

A comparison of the 95th percentile blood lead levels predicted for site visitors shows that recreational use at 22 of 24 properties may result in blood lead levels which exceed a target concentration of 11.1 ug/dL. This shows that several of these areas could pose a risk of elevated blood lead levels to teenage recreational visitors.

5.4   Direct Blood Lead Observations

5.4.1   Overview of Available Data

In June and July of 2000, the Central Utah Public Health Department (CUPHD) offered blood lead testing to children living in Eureka. Nineteen children under age 18 participated. Of these, 11 were found to have blood lead levels greater than 10 ug/dL. Based on these findings, the Environmental Epidemiology Program (EEP) at the Utah Department of Health petitioned ATSDR to fund an exposure investigation in Eureka. This study was performed in September and October of 2000 and blood lead testing was offered to all residents of Eureka. Participants were asked to complete surveys designed to identify potential sources of lead exposure.

During the year 2000, a total of **259** blood samples were collected from **227** Eureka residents. Of these participants, thirty-five (~15%) were found to have elevated blood lead levels (> 10 ug/dL). The results are summarized in Table 5-6, stratified by age. In most cases, only one blood lead value is available for each child. When more than one blood lead value was available, the first value was employed to calculate the statistics.

Follow up blood lead samples were collected from 32 of the 35 residents with elevated PbB values. These follow-up samples were collected 1-4 months after they were initially sampled. Overall, blood lead levels were found to decrease in the follow up sampling, however, levels remained elevated (>10 ug/dL) for 16 (50%) of these individuals.

Table 5-6 also compares the blood lead statistics for children living in Eureka with those for children across the United States who were studied in the third National Health and Nutrition Examination Study (NHANES III) over the time period 1988-1991 (Brody et al. 1994, Pirkle et al. 1994). In general, it is important to use caution in comparing national statistics with observations at a particular site. This is because there are so many independent variables that influence blood lead (age, race, sex, diet, socioeconomic status, environmental levels, time trends, etc.) that it is difficult to properly control for all fo the confounders. Nevertheless, comparisons of site data with national data do allow for a rough evaluation of site exposure levels with those in approximately similar groups of people across the nation. As seen, geometric mean blood lead levels in children (0 - 19 years) in Eureka in 2000 (3.1 to 9.1 ug/dL) are higher than the corresponding national geometric mean blood lead values (1.6 to 4.1 ug/dL).

5.4.2   Correlation of Blood Lead Values with Environmental Lead

During this study, 174 individuals consented to the use of their blood lead data to investigate the relationship between measured blood lead levels and the occurrence of lead in soil and other media. This relationship was investigated by plotting blood lead versus lead levels in soil and other potential sources, and calculating the best fit linear regression. Figure 5-4 shows the relationship between blood lead and soil lead concentrations in residential soil for all participants and for children 0-6 years of age. In addition to comparing blood lead to yard soils, this measurement was compared graphically to larger exposure areas (Figure 5-5). Figure 5-6 shows the comparison between dust concentration and blood lead as well as the comparison between dust loading and blood lead for all participants and for children 0-6 years of age. A comparison of paint concentration to blood lead for all participants and for children 0-6 years of age is shown in Figures 5-7 to 5-8.

Inspection of these figures reveals that there is no clear trend between blood lead and environmental lead concentrations or loading in residential soils, dust or paint. There appears to be substantial variability in blood lead values. High blood lead concentrations occur at both low and high environmental lead levels and low blood lead concentrations occur at both low and high environmental lead levels. This emphasizes that blood lead is a complex function of many variables, and soil lead concentrations alone are not the principle determinant.

5.4.3   Other Potential Determinants of Blood Lead

In addition to site-specific lead levels (i.e., soil, dust, paint, etc.), there are a number of other independent variables that may be important determinants of blood lead, including age, sex, mouthing habits, diet, socioeconomic status, exposure to tobacco smoke, etc. Limited data on some of these parameters were collected as part of surveys completed by study participants. A total of 174 of the 227 individuals in the

blood lead study consented to have identifying information released to USEPA for analysis of demographic and behavioral factors which could contribute to elevated blood lead levels. Forty-seven of these individuals were children ages 0-6. This data set was analyzed to determine if any other factors could be identified as being important determinants of blood lead levels in children. The resulting numbers presented in this report may not be equal to those summarized in the report prepared by UDOH, due to different data access agreements.

Figure 5-9 shows a plot of blood lead versus age for all study participants and for children, 0-6 years. As seen, there appears to be a slight decreasing trend in blood lead concentrations with age over all participants. The majority of the individuals with elevated blood leads (blood lead concentrations > 10 ug/dL) appear to be children, 0-13 years. A separate graph examines the blood lead versus age for children, 0-6 years. Based on this plot, there does not appear to be any trend in blood lead levels for children in this age bracket.

Other potential determinants of blood lead were investigated by evaluating the differences in blood lead levels between individuals based on their responses for each of the survey question parameters that might be important. The results are shown in Table 5-7. As seen, there was a significant difference (P<0.05) in blood lead levels of respondents for 7 survey question parameters: family member participating in lead battery work or ceramic painting activities, household tobacco use, and symptoms of weight loss, constipation and trouble sleeping in children. However, for all parameters except household tobacco use, this finding is based on a relatively small sample size (N= 2 to 4) for positive respondents. In contrast, the difference observed based on household tobacco use had a larger comparison population (N = 12), suggesting that exposure to tobacco smoke in the home may be an important influence on child blood lead levels.

5.4.4   Uncertainties Regarding Associations with Blood Lead Levels

The lack of statistically significant correlations between environmental media and blood lead levels does not imply that the lead in soil is not associated with the elevated blood lead levels seen in Eureka. Individual behavioral factors may strongly influence exposure to contaminated media, such as soil, resulting in differential intakes and blood lead levels. The existing data may not adequately allow us to understand those interactions and resulting consequences.

5.5   Weight of Evidence Evaluation

As noted above, evaluation of lead risks can be performed using either a modeling approach or direct observations. Because both of these approaches have advantages and limitations, it is important to compare and contrast the results of each approach.

One way to determine if the IEUBK model and measured blood lead concentrations are in agreement is to compare predicted blood lead values with measured values for individuals who participated in the biomonitoring study. To this end, the IEUBK model was used to calculate a predicted blood lead value

for each participating child less than 72 months of age (N=59), based on the IEUBK model input parameters described above, with the exception of using measured ages and environmental data where available. Results are shown in Figure 5-10 and summarized in Table 5-8. As seen in this figure, the model does not accurately predict values similar to those observed in children from this site. Predicted values did not consistently over-or underestimate the observed values for this site, rather the pattern appears to be highly variable.

In order to investigate the discrepancy between the observed blood lead concentrations in children and the values predicted by the IEUBK model, the residuals (the observed value subtracted from the value predicted by the model) was plotted against the lead concentrations in soil and dust to determine if the model accurately accounted for these variables. Figure 5-11 shows the resulting plots. As seen by the graphs, the IEUBK model appears to be systematically overestimating the contribution of soil and dust lead to a child's blood lead level.

Although the risks to lead are calculated on a property by property basis, for comparison purposes the summary table also provides statistics based on the exposure areas used to evaluate the non-lead COPC's. As shown in the summary table, 20 out of 59 children (34%) were observed to have elevated blood leads based on biomonitoring, whereas using a GSD of 1.4 or 1.6, the IEUBK model predicts that 50.3% and 50.6% of this subset of children will have elevated blood leads, respectively. Therefore, both the measured and modeled results suggest that elevated blood leads are of concern at this site.

5.6   Uncertainties

It is important to recognize that the exposure and risk calculations presented in this document are based on a number of assumptions, and that these assumptions introduce uncertainty into the exposure and risk estimates. Assumptions are required because of data gaps in our understanding of the toxicity of chemicals, and in our ability to estimate the true level of human exposure to chemicals. In most cases, assumptions employed in the risk assessment process to deal with uncertainties are intentionally conservative; that is, they are more likely to lead to an overestimate rather than an underestimate of risk. It is important for risk managers and the public to take these uncertainties into account when interpreting the risk conclusions derived for this site.

5.6.1   Uncertainty in Lead Concentration Estimates

Evaluation of human health risk at any particular location requires accurate information on the average concentration level of a chemical present at that location. As discussed previously, soil lead concentrations measured by XRF at each property required adjustment in order to reflect the discrepancy observed between XRF and ICP analyses. This adjustment resulted in an increase in overall lead concentrations by a factor of 49%. Although this adjustment introduces uncertainty into the concentration term, it is thought that the resulting risks are more representative of true lead exposures at this site.

5.6.2   Uncertainty in Lead Absorption from Soil

Another important source of uncertainty regarding the risk from lead in soil is the degree of absorption (RBA) within the gastrointestinal tract. For this risk assessment, a site-specific relative bioavailability factor for lead of 0.70 has been applied. However, this value is not based on direct measurements, but rather is extrapolated based on a comparison of lead phases in site soils with phases in other soils that have been previously tested for bioavailability. This introduces uncertainty because the selected value is not based on actual measurements for site soils. Soils are complex by nature and may have numerous attributes which influence overall absorptions characteristics. The selection process was based on mineral phase alone, and did not account for any other of these inherent properties. However, selection of this value is supported by data from Eureka samples tested for in vitro bioaccessability in which the average percent bioaccessability was estimated at 71%.

5.6.3   Uncertainty in Modeling Approach

As discussed in Section 5.2, the USEPA relies mainly on the IEUBK model to assess risks to children from lead exposure. One of the potential limitations to this model is that the distribution of blood lead values is based on an assumed GSD, rather than a direct evaluation of variability in exposure among different children. As discussed in Section 5.3, in order to address this potential limitation, USEPA Region 8 has been developing a modified version of the IEUBK model, referred to as the ISE Model for Lead. This approach uses the same basic equations and algorithms for calculating exposure and blood lead values as the IEUBK model, except that it uses probability distribution functions rather than point estimates as inputs for a number of exposure parameters. These distributions are combined using Monte Carlo simulation techniques to yield a predicted distribution of absorbed lead doses (ug/day) for different members of the exposed population. These doses are then used as input to the biokinetic portion of the IEUBK model in order to generate the predicted distribution of blood lead values in the population. Thus, the variability between children is evaluated in the ISE model based on the variability in environmental and exposure parameters, rather than by application of an assumed or estimated GSD value as in the IEUBK model. Because this model has not yet undergone peer review or validation, it is considered to be only an investigative tool. However, this model does provide useful information, and so it was used to help characterize uncertainty at this site.

The input distributions used in the ISE model runs are summarized in Appendix E. The basis of most of these distributions is provided in Goodrum et al. (1996). It is important to note that most of these distributions are screening-level only. In many cases a distribution is assumed to be lognormal, even though the true shape is not known. Likewise, the mean value of the distribution is selected to match the mean value used by the IEUBK model, but the estimate of the standard deviation is often an estimate based mainly on professional judgement. However, the single most important distribution (that for soil ingestion) is based on reliable data and a well-characterized empirical distribution function (EDF) reported by Stanek and Calabrese (1995). The mean soil intake value assumed by the IEUBK model (about 109 mg/day) is located between the 75th and 80th percentile of the EDF reported by Stanek and Calabrese (1995).

The results of a risk evaluation based on the ISE model compared to the predictions of the IEUBK model are presented below.

Model	# of properties	P10 Value (%)				Total with P10>5
		< 5%	5-10%	10-20%	> 20%	
IEUBK Model (GSD = 1.6)	505	0	5	19	481	505
ISE Model	505	189	55	57	204	316

As seen, both models suggest that concentrations of lead in soil pose a risk to current residents of the Eureka Mills site, as evidenced by the elevated P10 levels. However, the magnitude of these risks is much lower using the ISE model. Whereas the IEUBK model predicts that 100% of the residential properties will have P10 values greater than 5%, the ISE model predicts that only 63% will exceed this level. Although the predicted exceedances are lower using the ISE model, both models still predict a high likelihood of elevated blood lead levels at this site.

6.0   SUMMARY AND CONCLUSIONS

6.1   Risks from Non-Lead COPCs

Interpretation of risk characterization results is a matter of judgement by the risk manager. The measure used to describe the potential for noncarcinogenic toxicity to occur in an individual is expressed by comparing an exposure level over a specified time period with a reference dose derived for a similar exposure period. This ratio of exposure to toxicity is referred to as a hazard quotient.   To assess the overall potential for noncarcinogenic effects posed by more than one chemical, these HQs are summed to obtain a hazard index. In general , USEPA considers that acceptable level of excess risk under RME assumptions is an HI equal to or less than one (1E+00) for non-cancer risks. In this case, it is believed that there is no appreciable risk that noncancer health effects will occur. If an HI exceeds 1E+00, there is some possibility that noncancer effects may occur, although an HI above 1E+00 does not indicate an effect will definitely occur. In this instance, it is important to review the contribution of risks from the individual chemicals which were evaluated in the risk assessment.

In evaluating carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen. The level of total cancer risk that is of concern is a matter of personal, community and regulatory judgement. In general, it is the policy of the USEPA that remedial action is not warranted where excess cancer risks to the RME individual do not exceed a level of 1E-04 (USEPA 1991b). It should be noted that, the upper boundary of the risk range is not a discrete line at 1E-04. This risk level may be considered acceptable if justified based on site-specific conditions. However, a risk manager may also decide that a lower level of risk to human health is unacceptable and that remedial action is warranted where, for example, there are uncertainties in the risk assessment results.

A summary of the estimated non-cancer and cancer risks resulting from exposure to non-lead COPCs at this site is presented below. As discussed in Section 2, the following non-lead chemicals were selected for evaluation at this site.

Chemical	Soil COPC	Tap Water COPC
Antimony	X	
Arsenic	X	X
Cadmium	X	X
Iron	X	
Manganese	X	
Mercury	X	
Silver	X	
Thallium	X	

Current Residents

The soil/dust ingestion pathways resulted in an HI value in exceedence of 1E+00 at Areas 1 through 5, as well as across the site as a whole under the RME exposure scenario. No exceedences of this level of concern occurred under the average exposure scenario. Also, cancer risk from exposure to arsenic in soils and dust exceeded 1E-04 at Areas 3, 4, and 5 under the RME scenario. However, across the site as a whole and under the average exposure scenario the level of concern was not exceeded. For tap water ingestion pathways, the HI value for current residents did not exceed a value of 1E+00 at any individual exposure area or across the site as a whole under RME exposure conditions. Additionally, cancer risk from exposure to arsenic in tap water was not found to exceed 1E-04 at any evaluated area. The results of risk calculations presented in this report suggest that some excess cancer or non-cancer risks to current residents may be occurring from exposure to non-lead COPCs in soils, dust and drinking water, in accord with the numeric guidelines presented above.

Recreational Visitors

Risks to recreational visitors from soils at the non-residential properties surrounding Eureka were above a level of concern in several exposure areas. For non-cancer, HI values ranged from 2E+00 to 4E+00 under average exposure assumptions and from 9E+00 to 2E+01 under RME assumptions. For cancer risks under average exposure assumptions, no values were found to exceed a risk level of 1E-04. However, using RME assumptions these cancer risks ranged from 3E-04 to 7E-04. These results indicate that adverse effects could occur to recreational users of these current non-residential properties. Overall, these risks are primarily attributable to elevated concentrations of arsenic. As discussed in the uncertainty section of this document, these estimates of risks from arsenic may be biased high due to the use of exposure parameters (RBA, k_s) that are likely to be conservative.

Future Residents

Risks to future residents from soils at the non-residential properties surrounding Eureka were above general guidelines in several exposure areas. For non-cancer, HI values ranged from 1E+0 to 3E+0 under average exposure assumptions and from 4E+0 to 8E+00 under RME assumptions. For cancer risks under average exposure assumptions, no values were found to exceed a risk level of 1E-04. However, using RME assumptions these cancer risks ranged from 4E-04 to 8E-04. These results indicate that adverse effects could occur to future residents of these current non-residential properties. Overall, these risks are primarily attributable to elevated concentrations of arsenic. As discussed in the uncertainty section of this document, these estimates of risks from arsenic may be biased high due to the use of exposure parameters (RBA, k_s) that are likely to be conservative.

6.2   Risks from Lead

As discussed above, the USEPA has identified 10 ug/dL as the blood lead level at which effects that warrant avoidance begin to occur, and has set as a goal that there should be no more than a 5% chance that any child will have a blood lead value above 10 ug/dL (P10 < 5%) (USEPA 1994). This approach focuses on the risks to a child at the upper bound (about the 95th percentile) of the exposure distribution, very much the same way that the approach used for other chemicals focuses on risks to the RME individual.

Risks from lead exposure were evaluated at this site using both modeling approaches and direct blood lead observations. A summary of the estimated risks resulting from exposure to lead at this site is presented below. Risks were evaluated to current residential and hypothetical future residential children, as well as to teenage recreational visitors.

Current Residents

Using a GSD of 1.6 in the IEUBK model, 100% of children (age 0-6 years) residing at any of the 505 evaluated properties within Eureka are predicted to have blood lead P10 values exceeding 5%. Across these properties, the predicted P10 values were found to range from 7.3 to 99.9% with an average of 68.7%. When a GSD value of 1.4 was used in the model, P10 values were found to range from 2.1 to 100% (average 70.1%) with 99% of all exposures predicted to have a greater than 5% probability of exceeding a blood lead level of 10 ug/dL.

This predicted risk is supported by findings of a blood lead study conducted in Eureka in which 59 samples from children (<84 months in age) were assessed. Measured blood lead values were found to range from 2.2 to 34.2 ug/dL. A total of 20 (34%) of these blood lead levels were greater than 10 ug/dL.

Although both approaches show that elevated blood lead concentrations are present or likely to occur at this site, the IEUBK model failed to accurately predict blood lead concentrations in study participants,

suggesting that the model may not be accurately evaluating source exposures. Predicted values did not consistently over- or underestimate the observed values at this site, but rather the pattern appeared to be highly variable. A review of the model residuals showed that the IEUBK model had a tendency to systematically overestimate the contribution of soil and dust lead to a child's blood lead level. This indicates that additional factors may be contributing to the actual elevated blood lead levels observed in area children.

However, both the IEUBK model and the direct measurements support the conclusion that elevated blood lead levels are of concern to current residential children at this site. An alternate model known as the ISE model for lead, also supports this conclusion. This model was run in order to evaluate uncertainty in the modeling process as discussed in Section 5.6.3 of this report. Using this model, 63% of the evaluated properties are predicted to have P10 levels exceeding 5%.

Therefore, regardless of the evaluation approach for current residential children, exposure to lead at this site is expected to result in P10 values exceeding USEPA's established guidelines.

Future Residents

The IEUBK model was also used to predict blood lead levels in hypothetical future residential children living in the outlying areas of Eureka. A total of 24 outlying properties were evaluated. Predicted geometric mean blood lead concentrations were found to range from 6.3 to 82 ug/dL (average 33.4 ug/dL). This range exceeds that predicted by this model for the current residential properties. All of the evaluated properties were predicted to exceed a P10 value of 5%, regardless of the GSD value (1.6 or 1.4) utilized in the model. This indicates that if young children were to reside at these currently undeveloped properties, without reducing environmental lead concentrations, the risks of developing a blood lead value exceeding 10 ug/dL are suggested by the model to be quite likely.

Recreational Visitors

The Bowers model was utilized to predict the 95th Percentile blood lead concentration (PbB$_{95}$) in teenagers who may frequent non-residential areas for recreational purposes. The predicted blood lead values at the 24 evaluated properties were found to range from 2.8 to 98 ug/dL, with the maximum predicted value being seen in Area 5 (Upper Godiva Shaft). The PbB$_{95}$ concentrations were found to exceed a level of concern (11.1 ug/dL) at 22 properties, suggesting that recreational activities at the majority of the sampled properties may result in elevated blood lead levels.

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TABLES

Table 2-1: Summary Statistics for Data Set #1

Analyte	Analysis Method[+]	Detection Frequency (%)	Avg* (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	ICP	394/394 (100%)	11,826	1,100	20,000
Antimony	ICP	27/30 (90%)	19	10	59
Arsenic	ICP	394/394 (100%)	141	7.7	2,100
Barium	ICP	394/394 (100%)	326	91	1,200
Beryllium	ICP	394/394 (100%)	0.92	0.19	1.8
Cadmium	ICP	394/394 (100%)	19	0.5	140
Calcium	ICP	394/394 (100%)	49,968	5,200	250,000
Chromium	ICP	394/394 (100%)	17	2	110
Cobalt	ICP	394/394 (100%)	5.7	1.1	15
Copper	XRF	695/4211 (16%)	126	13	2,700
Iron	XRF	4208/4211 (99.9%)	19,649	5,600	88,000
Lead	XRF	3674/4211 (87%)	1,239	18	25,000
Magnesium	ICP	394/394 (100%)	18,741	2,100	84,000
Manganese	ICP	394/394 (100%)	1,054	220	5,100
Mercury	ICP	394/394 (100%)	3.3	0.04	130
Nickel	ICP	394/394 (100%)	12	3.4	34
Potassium	ICP	394/394 (100%)	3,346	390	6,200
Selenium	ICP	115/370 (31%)	0.79	0.5	8.3
Silver	ICP	351/384 (91%)	11	1	190
Sodium	ICP	394/394 (100%)	333	59	3,700
Thallium	ICP	53/391 (14%)	56	31	200
Vanadium	ICP	394/394 (100%)	26	7.7	330
Zinc	XRF	4068/4211 (97%)	1,460	26	44,000

* Non-Detects Evaluated at the Detection Limit
[+] XRF data used where deemed reliable, otherwise ICP data was used

Table 2-2: Summary Statistics for Data Set #2

Analyte	Analysis Method[+]	Non-Residential				Background			
		Detection Frequency (%)	Avg* (mg/kg)	Min (mg/kg)	Max (mg/kg)	Detection Frequency (%)	Avg* (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	ICP	36/36 (100%)	4,807	88	12,800	3/3 (100%)	9,583	7,240	11,700
Antimony	ICP	30/36 (83%)	43	0.5	330	0/3 (0%)	0.7	0.5	1.1
Arsenic	ICP	35/36 (97%)	414	0.4	1,100	3/3 (100%)	9.5	4.2	13.4
Barium	XRF	265/265 (100%)	622	57	3,600	18/18 (100%)	555	58	1,800
Beryllium	ICP	36/36 (100%)	0.56	0.1	1.4	3/3 (100%)	0.66	0.61	0.7
Cadmium	ICP	35/36 (97%)	60	0.2	171	3/3 (100%)	0.38	0.21	0.56
Calcium	XRF	265/265 (100%)	56,147	1,200	250,000	18/18 (100%)	41,295	1,200	132,000
Chromium	ICP	35/36 (97%)	14	0.3	220	3/3 (100%)	7.9	2.5	12.3
Cobalt	ICP	35/36 (97%)	5.65	0.2	17	3/3 (100%)	5.7	4.5	7.3
Copper	XRF	144/266 (54%)	279	74	2,200	0/18 (0%)	76	74	77
Iron	ICP	36/36 (100%)	21,774	61	48,500	3/3 (100%)	12,800	11,100	14,000
Lead	XRF	258/265 (97%)	4,065	32	51,000	17/18 (94%)	148	32	930
Magnesium	ICP	35/36 (97%)	22,950	23	79,000	3/3 (100%)	14,390	3,230	34,700
Manganese	ICP	36/36 (100%)	1,759	1	5,750	3/3 (100%)	441	117	710
Mercury	ICP	34/36 (94%)	10.2	0.05	144	2/3 (67%)	0.06	0.05	0.066
Nickel	ICP	34/36 (94%)	18	0.3	111	3/3 (100%)	9.5	1.9	16.9
Potassium	XRF	264/265 (99.6%)	16,277	2,200	35,000	18/18 (100%)	18,724	2,200	24,000
Selenium	ICP	35/36 (97%)	3.86	0.4	18	3/3 (100%)	0.97	0.8	1.2
Silver	ICP	32/36 (89%)	49	0.2	165	1/3 (33%)	0.2	0.2	0.2
Sodium	ICP	33/36 (92%)	758	42	1,830	0/3 (0%)	41.6	41.6	41.6
Thallium	ICP	27/36 (75%)	16	0.6	68	1/3 (33%)	0.77	0.6	1.1
Vanadium	ICP	35/36 (97%)	26	0.3	238	3/3 (100%)	23.2	15.6	31.8
Zinc	XRF	265/265 (100%)	4,198	54	26,000	16/18 (89%)	191	91	790

* Non-Detects Evaluated at the Detection Limit

[+] XRF data used where deemed reliable, otherwise ICP data was used

Table 2-3: Summary Statistics for Indoor Dust Analyzed via ICP

Analyte	Detection Frequency (%)	Avg (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	100%	7,562	2,770	14,900
Antimony	98%	5	0.2	20.5
Arsenic	100%	40	10.3	123
Barium	100%	282	70.8	2,060
Berylium	89%	0.4	0.14	1.9
Cadmium	100%	7.3	2	18.6
Calcium	100%	40,777	13,700	85,500
Chromium	100%	25	7.4	120
Cobalt	100%	3.8	1.1	11.8
Copper	100%	160	34.5	649
Iron	100%	9,429	3,300	27,300
Lead	100%	707	193	2010
Magnesium	100%	10,930	3,460	20,800
Manganese	100%	436	123	1,530
Mercury	100%	0.7	0.1	2.7
Nickel	100%	19	7.6	50.4
Potassium	100%	6,472	2,480	14,800
Selenium	53%	1.6	0.67	17.8
Silver	100%	4.3	1.1	10.8
Sodium	98%	26,212	18.9	171,000
Thallium	79%	1.3	0.32	3.7
Vanadium	100%	16	5.6	24.2
Zinc	100%	1,201	372	5,490

N = 57

Non Detects evaluated at the Detection Limit

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Table 2-4: Summary Statistics for Basement Soils Analyzed via ICP

Analyte	Detection Frequency (%)	Avg (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	7/7 (100%)	10,919	7,900	17,800
Antimony	1/7 (14%)	1.6	0.2	7.4
Arsenic	7/7 (100%)	29	6.8	131
Barium	7/7 (100%)	231	169	328
Beryllium	7/7 (100%)	0.7	0.61	0.87
Cadmium	7/7 (100%)	7.4	1.2	39.2
Calcium	7/7 (100%)	21,891	7,440	47,000
Chromium	7/7 (100%)	10	4.1	14.7
Cobalt	7/7 (100%)	5	3.4	6.4
Copper	7/7 (100%)	96	6.3	536
Iron	7/7 (100%)	15,843	10,100	29,200
Lead	7/7 (100%)	1,000	122	5,330
Magnesium	7/7 (100%)	5,234	3,090	8,990
Manganese	7/7 (100%)	481	282	732
Mercury	7/7 (100%)	2	0.14	10.3
Nickel	7/7 (100%)	11.5	5.1	17.9
Potassium	7/7 (100%)	2,763	1,970	3,680
Selenium	7/7 (100%)	1.3	0.28	4.9
Silver	7/7 (100%)	5.6	0.57	28.
Sodium	6/7 (86%)	371	17.7	869
Thallium	5/7 (71%)	1.7	0.34	6.6
Vanadium	7/7 (100%)	20	14.9	26.9
Zinc	7/7 (100%)	1,293	147	5,730

Non Detects Evaluated at the Detection Limit

Table 2-5: Summary Statistics for Eureka Paint Stratified by Condition

Exterior

Condition	Detection Freq.	Detects (mg/cm2)		
		Min	Max	Avg
cracking	1/1 (100%)	0.15	0.15	0.15
loose	1/1 (100%)	0.01	0.01	0.01
NA	1/1 (100%)	0.12	0.12	0.12
non-painted	--	--	--	--
peeling	4/17 (24%)	0.01	1.4	0.515
tight	4/8 (50%)	0.01	1.4	0.463
All	11/28 (39%)	0.01	1.4	0.252

Interior

Condition	Detection Freq.	Detects (mg/cm2)		
		Min	Max	Avg
cracking	1/1 (100%)	0.03	0.03	0.03
loose	4/6 (67%)	0.01	0.04	0.023
NA	0/1 (0%)	--	--	--
non-painted	0/3 (0%)	--	--	--
peeling	7/16 (44%)	0.01	1.7	0.371
tight	30/91 (33%)	0.01	1.7	0.184
All	42/118 (36%)	0.01	1.7	0.152

Analysis method is Pb L Line (measured at the paint surface)

Analyzed via XRF

NA refers to sites where the paint condition was not recorded in the field log book

Table 2-6: Summary Statistics for Tap Water Analyzed via ICP

Analyte	Detection Frequency (%)	Non-Detects Only (ug/L)			Detects Only (ug/L)		
		Avg	Min	Max	Avg	Min	Max
Aluminum	3/54 (6%)	29.4	19.3	34.9	36.7	31.6	43.5
Antimony	2/54 (4%)	1.94	1.9	2.3	2.15	2.1	2.2
Arsenic	25/54 (46%)	3.36	2.6	3.6	4.33	2.8	7.6
Barium	51/54 (94%)	2.09	0.38	3.5	103	82.1	129
Beryllium	0/54 (0%)	0.11	0.1	0.2	--	--	--
Cadmium	12/54 (22%)	0.29	0.2	0.51	0.70	0.34	2.2
Calcium	54/54 (100%)	--	--	--	69, 802	89	80, 800
Chromium	6/54 (11%)	0.65	0.5	1.4	0.80	0.51	0.94
Cobalt	0/54 (0%)	0.61	0.5	0.8	--	--	--
Copper	54/54 (100%)	--	--	--	281	6.3	1, 970
Iron	21/54 (39%)	23.2	10.8	100	123	12.4	471
Lead	19/54 (35%)	1.94	1.6	3.3	4.4 (excl. outlier)	2.1	38 (outlier) 13.8
Magnesium	53/54 (98%)	32.5	32.5	32.5	12703	223	14700
Manganese	33/54 (61%)	5.39	0.27	16.5	7.0	2.2	18.5
Mercury	2/54 (4%)	0.1	0.1	0.1	0.11	0.11	0.12
Nickel	45/54 (83%)	1.42	0.8	4.7	3.89	0.93	49.6
Potassium	53/54 (98%)	575	575	575	4787	383	5590
Selenium	5/54 (9%)	4.05	2.2	5	5.12	2.8	7.7
Silver	0/54 (0%)	0.89	0.6	3	--	--	--
Sodium	54/54 (100%)	--	--	--	33, 819	21800	130, 000
Thallium	3/54 (6%)	4.88	3.3	8.4	5.83	4.2	6.9
Vanadium	50/54 (93%)	3.83	3.5	4.2	3.99	1.3	4.8
Zinc	54/54 (100%)	--	--	--	501	45	4, 330

Table 2-7: Comparison of Detection Limits in Tap Water to RBCs

Analyte	Detection Frequency (%)	DL Range (ug/L)	RBC* (ug/L)	DL Adequate?[+]
Aluminum	3/54 (6%)	19.3-34.9	3,700	YES
Antimony	2/54 (4%)	1.9-2.3	1.5	YES
Arsenic	25/54 (46%)	2.6-3.6	0.45	NO
Barium	51/54 (94%)	0.38-3.5	260	YES
Beryllium	0/54 (0%)	0.1-0.2	7.3	YES
Cadmium	12/54 (22%)	0.2-0.51	1.8	YES
Calcium	54/54 (100%)	--	--	--
Chromium	6/54 (11%)	0.5-1.4	11**	YES
Cobalt	0/54 (0%)	0.5-0.8	220	YES
Copper	54/54 (100%)	--	--	--
Iron	21/54 (39%)	10.8-100	1,100	YES
Lead	19/54 (35%)	1.6-3.3	4 (EPA)	YES
Magnesium	53/54 (98%)	32.5-32.5	ntv	YES
Manganese	33/54 (61%)	0.27-16.5	510	YES
Mercury	2/54 (4%)	0.1-0.1	1.1	YES
Nickel	45/54 (83%)	0.8-4.7	73	YES
Potassium	53/54 (98%)	575-575	ntv	YES
Selenium	5/54 (9%)	2.2-5	18	YES
Silver	0/54 (0%)	0.6-3	18	YES
Sodium	54/54 (100%)	--	--	--
Thallium	3/54 (6%)	3.3-8.4	0.26	NO***
Vanadium	50/54 (93%)	3.5-4.2	26	YES
Zinc	54/54 (100%)	--	--	--

* Based on Region 3 Risk Based Concentrations at an HQ = 0.1 or Risk = 1E-05
[+] DL is Adequate if detection frequency is high (e.g., >80%), or if the DF is low but DL range is below the RBC
** Based on Chromium VI
*** A reconection and reanalysis of 10tapwater samples for thallium found that all samples were below a detection limit of 1 ug/L

Table 2-8: As Bioaccessibility Results for Eureka

(run at 1.5pH for 1 hour at 39 C)

	As In Bulk Soil (ppm)	Mass in Bulk Soil (g)	Calculated As #1	ICP As (mg/l)	Solution Amount (l)	As % Bioaccessable	pH Stop
EM-1	449	1.0022	0.45	0.489	0.1	10.9	1.617
EM-2	920	1.0035	0.92	0.611	0.1	6.6	1.875
EM-3	275	1.0042	0.28	0.115	0.1	4.2*	1.56
EM-4	189	1.0032	0.19	0.156	0.1	8.2*	1.74
EM-5	148	1.0063	0.15	0.062	0.1	4.2*	1.718
EM-6	287	1.0077	0.29	0.240	0.1	8.3	1.572
EM-7	1301	1.0076	1.31	1.042	0.1	8.0	1.641
EM-8	54	1.0038	0.05	0.166	0.1	30.7*	1.585
EM-9	3	1.0036	0	0.00	0.1	0*	1.526
EM-10	29	1.007	0.03	0.052	0.1	17.9*	1.629
EM-11	1440	1.0013	1.44	0.955	0.1	6.6	1.734
EM-12	99	1.0068	0.1	0.255	0.1	25.6	1.665
EM-13	363	1.0022	0.36	0.241	0.1	6.6	1.69
EM-14	385	1.0032	0.39	0.183	0.1	4.7*	1.565
EM-15	650	1.0043	0.65	0.252	0.1	3.9	2.017
EM-16	696	1.0035	0.7	1.603	0.1	22.9	1.687
EM-17	506	1.0045	0.51	2.141	0.1	42.1	1.668
Detection Limit	17			0.230			

*The bioaccessibility values for this sample may not be meaningful because the total As
in the bulk soil and/or the As in the invitro solution are below or near the detection limit of the
respective analytical equipment.

Shading indicates the bioaccessibility column

Table 2-9: Pb Bioaccessibility Results for Eureka

(run at 1.5pH for 1 hour at 39 C)

	Pb In Bulk Soil (ppm)	Mass in Bulk Soil (g)	Calculated Pb #1	ICP Pb (mg/l)	Solution Amount (l)	Pb % Bioaccessable	pH Stop
EM-1	9820	1.00221	9.84	73	0.1	73.8	1.617
EM-2	17744	1.00349	17.81	111	0.1	62.4	1.875
EM-3	5995	1.00424	6.02	46	0.1	76.5	1.56
EM-4	3718	1.00318	3.73	25	0.1	68.3	1.74
EM-5	2522	1.00628	2.54	17	0.1	66.1	1.718
EM-6	8771	1.00774	8.84	72	0.1	81.5	1.572
EM-7	23445	1.00775	23.62	174	0.1	73.8	1.641
EM-8	2154	1.00382	2.16	15	0.1	70.1	1.585
EM-9	551	1.00364	0.55	4	0.1	69.1	1.528
EM-10	1055	1.00698	1.06	7	0.1	69.8	1.629
EM-11	12955	1.00125	12.97	86	0.1	66	1.734
EM-12	4065	1.00679	4.09	29	0.1	69.8	1.665
EM-13	10752	1.00216	10.78	64	0.1	59.6	1.69
EM-14	10898	1.00321	10.93	89	0.1	81.3	1.565
EM-15	12998	1.00431	13.05	80	0.1	61.5	2.017
EM-16	23604	1.00351	23.69	180	0.1	76.2	1.687
EM-17	14522	1.00445	14.59	129	0.1	88.7	1.668
Detection Limit	35			0.047			

Shading indicates the bioaccessibility column

Table 2-10: Evaluation of Beneficial and Essential Minerals in Soil and Water

PART A: EVALUATION OF BENEFICIAL AND ESSENTIAL MINERALS IN SOIL

Chemical	Max Conc[a] mg/kg	TWA-Intake[b] kg/kg-day	Max DI[c] mg/kg-day	RDA[d] mg/kg-day	Ratio DI/RDA	Retain
Calcium	250,000	3.65E-06	9.13E-01	14	0.065	NO
Cobalt	17	3.65E-06	6.21E-05	0.06	0.001	NO
Chromium (III)	220	3.65E-06	8.04E-04	1	<0.001	NO
Copper	2,900	3.65E-06	1.06E-02	0.037	0.286	NO
Iron	83,000	3.65E-06	3.03E-01	0.3	1.166	**YES**
Magnesium	84,000	3.65E-06	3.07E-01	5.7	0.054	NO
Manganese	5,750	3.65E-06	2.10E-02	0.005	4.201	**YES**
Potassium	6,200	3.65E-06	2.26E-02	0.57	0.040	NO
Selenium	18	3.65E-06	6.58E-05	0.005	0.013	NO
Sodium	3,700	3.65E-06	1.35E-02	34	<0.001	NO
Zinc	26,000	3.65E-06	9.50E-02	0.30	0.317	NO

PART B: EVALUATION OF BENEFICIAL AND ESSENTIAL MINERALS IN WATER

Chemical	Max Conc[a] mg/L	TWA-Intake[b] L/kg-day	Max DI[c] mg/kg-day	RDA[d] mg/kg-day	Ratio DI/RDA	Retain
Calcium	81	3.47E-02	2.80E+00	14	0.200	NO
Cobalt	--	3.47E-02	--	0.06	--	--
Chromium (III)	0.0014	3.47E-02	4.86E-05	1	<0.001	NO
Copper	1.97	3.47E-02	6.84E-02	0.037	1.848	**YES**
Iron	0.47	3.47E-02	1.63E-02	0.3	0.063	NO
Magnesium	15	3.47E-02	5.10E-01	5.7	0.089	NO
Manganese	0.02	3.47E-02	6.59E-04	0.005	0.132	NO
Potassium	6	3.47E-02	1.94E-01	0.57	0.340	NO
Selenium	0.0077	3.47E-02	2.67E-04	0.005	0.053	NO
Sodium	130	3.47E-02	4.51E+00	34	0.133	NO
Zinc	4.33	3.47E-02	1.50E-01	0.30	0.501	NO

[a] Maximum detected concentration

[b] TWA-Intake = Time-weight average intake rate of environmental medium (RME Resident)

   Soil: Assumes ingestion of 200 mg/d for 6 years (as 15 kg child) and 100 mg/d for 24 years (as 70 kg adult) for 350 days/yr

   Water: Assumes ingestion of 1 L/d for 6 years (as 15 kg child) and 2 L/d for 24 years (as 70 kg adult) for 350 days/yr

[c] DI = Daily intake of chemical (mg/kg-day)

[d] RDA = Recommended Dietary Allowance or Toxicity Value from USEPA (1994)

   Sodium value based on 2,400 mg/day recommended daily allowance divided by 70 kg body weight

I:\Eureka\Risk Calcs\COPCs\max concs vs Reg 3.xls

Table 2-11: Maximum and Average Chemical Concentrations in Soil and Background Concentrations in the United States

Chemical	Max Soil Conc (mg/kg) *	Avg Residential Soil Conc (mg/kg) *	Avg Non-residential Soil Conc (mg/kg) *	Background Concentrations for Soils in the Western United States**		Background Concentrations for Soils in the United States***	Background Concentrations for Soils in the United States****		Retain?
				Range (ppm)	Geometic Mean	Range (ppm)	Range (ppm)	Mean	
Aluminum	20,000	11,826	4,807	0.5 - >10[+]	5.8[+]	10,000 - 300,000	5,000 - 100,000	54,000	NO
Antimony	330	19	43	<1 - 2.6	0.5	0.6 - 10			YES
Arsenic	2,100	141	414	<0.10 - 97	5.5	1.0 - 40	1 - 40	5.0	YES
Barium	1,200	326	324	70 - 5,000	580	100 - 3,500	15 - 3,000 15 - 1,000		NO
Beryllium	1.8	0.9	0.6	<1 - 15	0.7	0.1 - 40	0.13 - 0.88	0	NO
Cadmium	171	19	60	<150 - 300	65	0.01 - 7.0		0	YES
Iron	83,000	18,576	21,774	0.1 - >10	2.1	7,000 - 550,000			YES
Lead	82,700	2,987	16,366	<10 - 700	17	2.0 - 200			YES
Manganese	5,750	1,054	1,759	30 - 5,000	380	600-6,000	40 - 900	330	YES
Mercury	144	3.3	10	<.01 - 4.6	0.05	0.01 - 0.08			YES
Nickel	111	12	18	<5 - 700	15	5.0 - 1,000	5 - 700	13	NO
Rubidium	140		87	<20 - 210	69	20 - 600			NO
Silver	190	10	49	NA	NA	0.1 - 5.0			YES
Strontium	490		242	10 - 3000	200	50 - 1000			NO
Thallium	200	55	16	NA	NA	NA	trace amounts		YES
Titanium	4700		1882	0.05 - 2.0	0.22	1000 - 10000			YES
Vanadium	330	26	26	7 - 500	70	20 - 500			NO
Zirconium	400		204	<20 - 1500	160	60 - 2000			NO

* Maximum from either outside soils or residential soils

** Based on Shacklette and Boerngen, 1984

*** Based on Dragun, 1988

**** Based on ATSDR, 1997

[+] These values are several orders of magnitude smaller than that of the other studies; these values may have been reported with a units error. Therefore, we are disregarding these values in our analysis.

Table 2-12: Maximum Chemical Concentrations in Soil and Water and Region 3 RBC Standards

Part A: Soil

Chemical	Max Outside Soil Conc (mg/kg)	Max Residential Soil Conc (mg/kg)	Max Soil Conc (mg/kg) *	Region III Soil RBC (mg/kg)**	Retain as COPC?
Antimony	330	59	330	3	**YES**
Arsenic	1,100	2,100	2,100	0.004	**YES**
Cadmium	171	140	171	8	**YES**
Iron	48,500	83,000	83,000	23,000	**YES**
Lead	82,700	37,000	82,700	400	**YES**
Manganese	5,750	5,100	5,750	160	**YES**
Mercury	144	130	144	2.2	**YES**
Silver	165	190	190	39	**YES**
Thallium	68	200	200	0.6	**YES**
Titanium	4700		4700	31,000	NO

Part B: Water

Chemical	Max Tap Water Conc (ug/L)	Region III Water RBC (ug/L)**	Retain as COPC?
Aluminum	44	3,700	NO
Arsenic	7.6	0.0005	**YES**
Barium	129	260	NO
Cadmium	2.2	2	**YES**
Copper	1,970	1,500	**YES**
Lead	14	4	**YES**
Nickel	50	73	NO
Vanadium	4.8	26	NO

* Maximum of UCL95 soil concentration from either outside soils or residential soils

** Based on HQ = 0.1 or Risk = 1E-06

I: Eureka\ Risk Calcs\COPCs\ max concs vs Reg 3.xls

Table 4-1: Summary Statistics for Residential Surface Soils

Chemical	Location	Detect Frequency	Max Value (mg/kg)	Min Value (mg/kg)	Mean (mg/kg)	UCL95 Norm	UCL95 LogNorm	EPC (mg/kg)
Antimony	1	2/3	1.2E+01	5.0E+00	9.3E+00	1.6E+01	9.0E+01	1.2E+01
	2	0/1	5.0E+00	5.0E+00	5.0E+00	--	--	5
	3	1/1	1.3E+01	1.3E+01	1.3E+01	--	--	1.3E+01
	4	--	--	--	--	--	--	--
	5	1/1	1.1E+01	1.1E+01	1.1E+01	--	--	1.1E+01
	6	--	--	--	--	--	--	--
	All	4/6	1.3E+01	5.0E+00	9.5E+00	1.2E+01	1.5E+01	1.3E+01
Arsenic	1	55/55	5.6E+02	9.5E+00	8.0E+01	1.0E+02	1.0E+02	101.1244
	2	32/32	2.6E+02	1.2E+01	7.2E+01	9.0E+01	9.9E+01	9.9E+01
	3	9/9	2.4E+02	8.0E+00	5.0E+01	9.6E+01	1.5E+02	1.5E+02
	4	32/32	2.9E+02	7.7E+00	9.0E+01	1.1E+02	1.2E+02	1.2E+02
	5	21/21	2.2E+02	2.0E+01	7.6E+01	9.6E+01	1.1E+02	1.1E+02
	6	--	--	--	--	--	--	--
	All	149/149	5.6E+02	7.7E+00	7.8E+01	8.8E+01	9.0E+01	89.83637
Cadmium	1	46/46	6.1E+01	1.5E+00	1.5E+01	1.8E+01	1.9E+01	1.9E+01
	2	29/29	3.9E+01	1.9E+00	9.5E+00	1.2E+01	1.3E+01	1.3E+01
	3	9/10	4.5E+01	2.5E-01	7.6E+00	1.5E+01	6.5E+01	4.5E+01
	4	27/27	4.0E+01	1.4E+00	1.4E+01	1.8E+01	2.1E+01	2.1E+01
	5	20/20	5.9E+01	4.6E+00	1.5E+01	2.1E+01	2.1E+01	2.1E+01
	6	--	--	--	--	--	--	--
	All	131/132	6.1E+01	2.5E-01	1.3E+01	1.5E+01	1.6E+01	1.6E+01
Iron*	1	546/546	3.2E+04	6.1E+03	1.8E+04	1.9E+04	1.9E+04	18536.51
	2	292/292	2.8E+04	7.7E+03	1.6E+04	1.6E+04	1.6E+04	1.6E+04
	3	142/142	1.9E+04	1.0E+04	1.6E+04	1.6E+04	1.6E+04	16026.16
	4	304/304	3.6E+04	1.1E+04	1.7E+04	1.7E+04	1.7E+04	1.7E+04
	5	283/283	3.9E+04	8.8E+03	1.7E+04	1.7E+04	1.7E+04	1.7E+04
	6	120/120	7.0E+04	1.2E+04	1.8E+04	1.9E+04	1.8E+04	1.9E+04
	All	1000/1000	3.2E+04	6.1E+03	1.7E+04	1.7E+04	1.7E+04	17417.63
Manganese	1	38/38	3.5E+03	2.2E+02	9.2E+02	1.1E+03	1.1E+03	1.1E+03
	2	29/29	3.0E+03	3.3E+02	8.0E+02	9.8E+02	9.5E+02	9.8E+02
	3	10/10	2.6E+03	3.2E+02	7.7E+02	1.2E+03	1.3E+03	1.3E+03
	4	25/25	2.5E+03	4.3E+02	9.2E+02	1.1E+03	1.0E+03	1.1E+03
	5	18/18	1.8E+03	4.7E+02	7.7E+02	8.9E+02	8.8E+02	8.9E+02
	6	--	--	--	--	--	--	--
	All	120/120	3.5E+03	2.2E+02	8.6E+02	9.4E+02	9.2E+02	9.4E+02
Mercury	1	50/50	2.0E+01	6.4E-02	1.6E+00	2.3E+00	2.0E+00	2.3E+00
	2	29/29	7.6E+00	6.0E-02	1.1E+00	1.6E+00	1.8E+00	1.8E+00
	3	10/10	2.1E+00	6.1E-02	5.0E-01	8.7E-01	2.1E+00	2.1E+00
	4	29/29	1.0E+01	1.5E-01	2.1E+00	2.8E+00	3.4E+00	3.4E+00
	5	18/18	2.9E+01	1.3E-01	2.9E+00	5.6E+00	5.6E+00	5.6E+00
	6	--	--	--	--	--	--	--
	All	136/136	2.9E+01	6.0E-02	1.7E+00	2.2E+00	2.0E+00	2.2E+00

Chemical	Location	Detect Frequency	Max Value (mg/kg)	Min Value (mg/kg)	Mean (mg/kg)	UCL95		EPC (mg/kg)
						Norm	LogNorm	
Silver	1	46/48	2.9E+01	5.0E-01	6.6E+00	8.2E+00	9.1E+00	9.1E+00
	2	27/29	8.8E+00	5.0E-01	3.8E+00	4.6E+00	5.6E+00	5.6E+00
	3	4/5	1.3E+01	5.0E-01	4.2E+00	9.1E+00	2.2E+02	1.3E+01
	4	28/29	1.9E+01	5.0E-01	6.2E+00	7.6E+00	9.3E+00	9.3E+00
	5	22/22	5.6E+01	1.5E+00	1.0E+01	1.5E+01	1.7E+01	1.7E+01
	6	--	--	--	--	--	--	--
	All	127/133	5.6E+01	5.0E-01	6.4E+00	7.5E+00	7.6E+00	7.6E+00
Thallium	1	5/6	1.5E+02	2.5E+01	8.4E+01	1.2E+02	1.8E+02	1.5E+02
	2	0/2	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01
	3	0/2	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01
	4	1/3	5.4E+01	2.5E+01	3.5E+01	6.3E+01	1.8E+02	5.4E+01
	5	0/2	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01
	6	--	--	--	--	--	--	--
	All	6/15	1.5E+02	2.5E+01	5.0E+01	6.8E+01	7.3E+01	7.3E+01

-- No data available

UCL = 95% upper confidence limit of the mean

EPC = Exposure Point Concentration, defined as the UCL or the maximum, whichever is lower

* Iron data is based on adjusted XRF dataset

Table 4-2: Summary Statistics for Indoor Dust

Chemical	Location	Detect Frequency	Max Value (mg/kg)	Min Value (mg/kg)	Mean (mg/kg)	UCL95 Norm	UCL95 LogNorm	EPC (mg/kg)
Antimony	1	18/19	2.1E+01	7.0E-01	6.5E+00	8.5E+00	1.0E+01	10.23387
	2	10/10	5.9E+00	2.0E+00	3.6E+00	4.2E+00	4.4E+00	4.4E+00
	3	--	--	--	--	--	--	--
	4	13/13	1.2E+01	3.1E+00	6.1E+00	7.5E+00	7.9E+00	7.9E+00
	5	8/8	7.6E+00	2.2E+00	5.0E+00	6.4E+00	7.5E+00	7.5E+00
	6	--	--	--	--	--	--	--
	All	50/51	2.1E+01	7.0E-01	5.5E+00	6.4E+00	6.5E+00	6.5E+00
Arsenic	1	23/23	1.2E+02	1.0E+01	4.3E+01	5.1E+01	5.6E+01	5.6E+01
	2	11/11	4.1E+01	1.1E+01	2.5E+01	3.1E+01	3.4E+01	3.4E+01
	3	--	--	--	--	--	--	--
	4	14/14	6.3E+01	1.4E+01	4.1E+01	4.9E+01	5.4E+01	5.4E+01
	5	8/8	7.4E+01	1.9E+01	4.3E+01	5.5E+01	6.3E+01	6.3E+01
	6	--	--	--	--	--	--	--
	All	57/57	1.2E+02	1.0E+01	4.0E+01	4.4E+01	4.6E+01	45.84195
Cadmium	1	21/21	1.2E+01	2.0E+00	7.7E+00	8.8E+00	9.4E+00	9.4E+00
	2	11/11	1.0E+01	2.2E+00	5.7E+00	7.0E+00	7.6E+00	7.6E+00
	3	--	--	--	--	--	--	--
	4	14/14	1.9E+01	2.1E+00	7.7E+00	9.7E+00	1.1E+01	1.1E+01
	5	8/8	1.4E+01	3.4E+00	8.0E+00	1.0E+01	1.2E+01	1.2E+01
	6	--	--	--	--	--	--	--
	All	55/55	1.9E+01	2.0E+00	7.4E+00	8.1E+00	8.4E+00	8.4E+00
Iron	1	21/21	1.4E+04	3.3E+03	9.6E+03	1.1E+04	1.2E+04	1.2E+04
	2	11/11	1.1E+04	4.0E+03	7.8E+03	9.2E+03	9.9E+03	9.9E+03
	3							
	4	14/14	2.7E+04	4.2E+03	1.0E+04	1.3E+04	1.3E+04	1.3E+04
	5	7/7	1.3E+04	4.7E+03	9.7E+03	1.2E+04	1.3E+04	1.3E+04
	6	--	--	--	--	--	--	--
	All	54/54	2.7E+04	3.3E+03	9.3E+03	1.0E+04	1.0E+04	1.0E+04
Manganese	1	23/23	1.5E+03	1.2E+02	4.7E+02	5.7E+02	5.9E+02	5.9E+02
	2	10/10	4.7E+02	1.8E+02	3.4E+02	4.0E+02	4.3E+02	4.3E+02
	3	--	--	--	--	--	--	--
	4	14/14	6.1E+02	1.8E+02	4.3E+02	4.9E+02	5.3E+02	5.3E+02
	5	8/8	7.1E+02	1.8E+02	4.9E+02	6.1E+02	7.3E+02	7.1E+02
	6	--	--	--	--	--	--	--
	All	56/56	1.5E+03	1.2E+02	4.4E+02	4.8E+02	4.9E+02	4.9E+02
Mercury	1	21/21	2.7E+00	1.6E-01	7.4E-01	9.6E-01	1.0E+00	1.0E+00
	2	10/10	9.4E-01	1.0E-01	4.0E-01	5.8E-01	8.2E-01	8.2E-01
	3	--	--	--	--	--	--	--
	4	11/11	2.2E+00	4.0E-01	9.4E-01	1.2E+00	1.4E+00	1.4E+00
	5	7/7	9.4E-01	1.2E-01	4.8E-01	6.7E-01	1.0E+00	9.4E-01
	6							
	All	50/50	2.7E+00	1.0E-01	6.7E-01	7.9E-01	8.4E-01	8.4E-01

Chemical	Location	Detect Frequency	Max Value (mg/kg)	Min Value (mg/kg)	Mean (mg/kg)	UCL95 Norm	UCL95 LogNorm	EPC (mg/kg)
Silver	1	19/19	1.1E+01	1.1E+00	4.6E+00	5.5E+00	6.2E+00	6.2E+00
	2	9/9	8.4E+00	1.1E+00	3.7E+00	5.1E+00	6.4E+00	6.4E+00
	3	--	--	--	--	--	--	--
	4	14/14	1.1E+01	1.9E+00	4.6E+00	5.7E+00	5.9E+00	5.9E+00
	5	8/8	5.9E+00	3.4E+00	4.4E+00	5.0E+00	5.2E+00	5.2E+00
	6	--	--	--	--	--	--	--
	All	51/51	1.1E+01	1.1E+00	4.4E+00	4.9E+00	5.0E+00	5.0E+00
Thallium	1	17/19	2.9E+00	2.1E-01	1.2E+00	1.5E+00	1.9E+00	1.9E+00
	2	4/8	1.2E+00	1.6E-01	5.7E-01	8.5E-01	1.7E+00	1.2E+00
	3	--	--	--	--	--	--	--
	4	11/13	3.6E+00	1.6E-01	1.4E+00	2.0E+00	3.9E+00	3.6E+00
	5	5/7	3.7E+00	1.7E-01	1.5E+00	2.5E+00	2.0E+01	3.7E+00
	6	--	--	--	--	--	--	--
	All	38/48	3.7E+00	1.6E-01	1.2E+00	1.5E+00	1.8E+00	1.8E+00

-- No data available

UCL = 95% upper confidence limit of the mean

EPC = Exposure Point Concentration, defined as the UCL or the maximum, whichever is lower

Table 4-3: Summary Statistics for Residential Tap Water

Chemical	Location	Medium	Detection Frequency	Max Value (ppb)	Min Value (ppb)	Mean (ppb)	UCL95		EPC (ppb)
							Norm	LogNorm	
Arsenic	All	Tap Water	25/54	7.6	1.3	2.9	3.3	3.3	3.3
Cadmium	All	Tap Water	12/54	2.2	0.1	0.3	0.3	0.3	0.3

Table 4-4: Summary Statistics for Non-Residential Surface Soils

Chemical	Location	Detect Frequency	Max Value (mg/kg)	Min Value (mg/kg)	Mean (mg/kg)	UCL95 Norm	UCL95 LogNorm	EPC (mg/kg)
Antimony	A	4/4	1.1E+02	2.8E+01	5.8E+01	9.9E+01	1.7E+02	1.1E+02
	B	--	--	--	--	--	--	--
	C	5/5	2.5E+01	9.9E-01	1.6E+01	2.5E+01	1.4E+03	24.8
	D	3/3	6.8E+01	8.6E+00	4.2E+01	9.2E+01	1.5E+06	6.8E+01
	E	5/5	3.3E+02	2.7E+01	1.1E+02	2.3E+02	1.2E+03	3.3E+02
	F	6/6	7.9E+01	1.3E+01	4.6E+01	7.0E+01	1.5E+02	7.9E+01
	G	--	--	--	--	--	--	--
	All	23/23	3.3E+02	9.9E-01	5.5E+01	7.9E+01	1.3E+02	1.3E+02
Arsenic	A	4/4	6.4E+02	2.0E+02	3.8E+02	6.3E+02	1.2E+03	637
	B	--	--	--	--	--	--	--
	C	5/5	5.3E+02	2.4E+00	2.7E+02	4.9E+02	7.0E+08	5.3E+02
	D	3/3	8.6E+02	7.9E+01	4.7E+02	1.1E+03	1.2E+09	8.6E+02
	E	5/5	1.1E+03	2.5E+02	7.9E+02	1.1E+03	2.3E+03	1.1E+03
	F	6/6	1.1E+03	2.6E+02	6.5E+02	9.3E+02	1.4E+03	1.1E+03
	G	--	--	--	--	--	--	--
	All	23/23	1.1E+03	2.4E+00	5.3E+02	6.5E+02	1.9E+03	1100
Cadmium	A	4/4	1.7E+02	3.9E+01	7.5E+01	1.5E+02	3.5E+02	1.7E+02
	B	--	--	--	--	--	--	--
	C	5/5	1.4E+02	2.1E-01	5.3E+01	1.2E+02	2.9E+09	1.4E+02
	D	3/3	5.9E+01	2.9E+01	4.3E+01	6.8E+01	1.6E+02	5.9E+01
	E	5/5	1.6E+02	2.6E+01	1.1E+02	1.6E+02	4.7E+02	1.6E+02
	F	6/6	1.2E+02	4.0E+01	7.5E+01	9.8E+01	1.1E+02	1.1E+02
	G	--	--	--	--	--	--	--
	All	23/23	1.7E+02	2.1E-01	7.3E+01	9.2E+01	4.0E+02	1.7E+02
Iron	A	4/4	3.5E+04	1.5E+04	2.6E+04	3.7E+04	5.0E+04	3.5E+04
	B	--	--	--	--	--	--	--
	C	5/5	3.1E+04	1.3E+04	2.3E+04	3.1E+04	3.9E+04	3.1E+04
	D	3/3	1.9E+04	1.5E+04	1.7E+04	2.0E+04	2.1E+04	1.9E+04
	E	5/5	4.0E+04	2.0E+04	2.9E+04	3.6E+04	4.0E+04	4.0E+04
	F	6/6	2.6E+04	1.6E+04	2.1E+04	2.4E+04	2.4E+04	2.4E+04
	G	--	--	--	--	--	--	--
	All	23/23	4.0E+04	1.3E+04	2.4E+04	2.6E+04	2.7E+04	2.7E+04
Manganese	A	4/4	2.5E+03	1.4E+03	1.8E+03	2.4E+03	2.6E+03	2.5E+03
	B	--	--	--	--	--	--	--
	C	5/5	3.4E+03	1.5E+01	1.4E+03	2.7E+03	1.3E+08	3.4E+03
	D	3/3	1.2E+03	4.9E+02	8.7E+02	1.5E+03	7.7E+03	1.2E+03
	E	5/5	5.8E+03	1.9E+03	4.4E+03	5.9E+03	8.3E+03	5.8E+03
	F	6/6	4.1E+03	1.4E+03	2.1E+03	3.0E+03	3.5E+03	3.5E+03
	G	--	--	--	--	--	--	--
	All	23/23	5.8E+03	1.5E+01	2.2E+03	2.8E+03	6.9E+03	5.8E+03
Mercury	A	4/4	6.2E+00	1.2E+00	3.2E+00	5.8E+00	1.6E+01	6.2E+00
	B	--	--	--	--	--	--	--
	C	5/5	4.7E+00	6.1E-01	2.6E+00	4.2E+00	2.0E+01	4.7E+00
	D	3/3	1.4E+02	1.7E+00	7.2E+01	1.9E+02	3.3E+26	1.4E+02
	E	5/5	6.3E+00	2.7E+00	4.3E+00	5.6E+00	6.3E+00	6.3E+00
	F	6/6	1.2E+00	2.8E-01	6.8E-01	9.9E-01	1.4E+00	1.2E+00
	G	--	--	--	--	--	--	--
	All	23/23	1.4E+02	2.8E-01	1.2E+01	2.3E+01	2.1E+01	2.3E+01

Chemical	Location	Detect Frequency	Max Value (mg/kg)	Min Value (mg/kg)	Mean (mg/kg)	UCL95 Norm	UCL95 LogNorm	EPC (mg/kg)
Silver	A	4/4	1.1E+02	6.2E+00	4.4E+01	9.7E+01	3.3E+03	1.1E+02
	B	--	--	--	--	--	--	--
	C	4/5	1.1E+02	1.0E-01	4.2E+01	9.5E+01	3.6E+11	1.1E+02
	D	3/3	9.0E+01	2.7E+01	5.8E+01	1.1E+02	1.7E+03	9.0E+01
	E	5/5	6.3E+01	2.7E+01	4.3E+01	5.6E+01	6.3E+01	6.3E+01
	F	6/6	1.4E+02	1.5E+01	7.6E+01	1.2E+02	2.8E+02	1.4E+02
	G	--	--	--	--	--	--	--
	All	22/23	1.4E+02	1.0E-01	5.4E+01	6.8E+01	4.3E+02	1.4E+02
Thallium	A	4/4	5.1E+01	1.1E+01	2.6E+01	4.6E+01	1.1E+02	5.1E+01
	B	--	--	--	--	--	--	--
	C	4/5	6.1E+01	3.0E-01	2.0E+01	4.3E+01	6.7E+05	6.1E+01
	D	2/3	6.9E+00	1.6E+00	4.6E+00	9.3E+00	2.0E+03	6.9E+00
	E	5/5	6.8E+01	8.1E+00	4.8E+01	7.0E+01	4.1E+02	6.8E+01
	F	6/6	2.7E+01	6.8E+00	1.3E+01	1.9E+01	2.3E+01	2.3E+01
	G	--	--	--	--	--	--	--
	All	21/23	6.8E+01	3.0E-01	2.3E+01	3.1E+01	6.6E+01	6.6E+01

-- No data available

UCL = 95% upper confidence limit of the mean

EPC = Exposure Point Concentration, defined as the UCL or the maximum, whichever is lower

Table 4-5: Risk Estimates for Residential Soil Ingestion (by area)

Part A: Evaluation of Chronic Non-Cancer Risk

Analyte	All Areas Avg	All Areas RME	Area 1 Avg	Area 1 RME	Area 2 Avg	Area 2 RME	Area 3 Avg	Area 3 RME	Area 4 Avg	Area 4 RME	Area 5 Avg	Area 5 RME	Area 6 Avg	Area 6 RME
Antimony	3.0E-02	8.5E-02	3.4E-02	9.4E-02	1.5E-02	4.2E-02	3.0E-02	8.5E-02	1.3E-02	3.8E-02	2.8E-02	7.9E-02		
Arsenic	1.5E-01	4.3E-01	1.8E-01	4.9E-01	1.4E-01	4.0E-01	1.9E-01	5.2E-01	2.1E-01	5.7E-01	2.0E-01	5.6E-01		
Cadmium	1.5E-02	4.3E-02	1.8E-02	5.0E-02	1.3E-02	3.7E-02	3.2E-02	9.0E-02	2.0E-02	5.6E-02	2.1E-02	5.9E-02		
Iron	5.9E-02	1.6E-01	6.4E-02	1.8E-01	5.6E-02	1.6E-01	3.1E-02	8.8E-02	6.5E-02	1.8E-01	6.3E-02	1.8E-01	3.7E-02	1.0E-01
Manganese	6.5E-03	1.8E-02	7.7E-03	2.1E-02	6.3E-03	1.8E-02	8.0E-03	2.2E-02	7.1E-03	2.0E-02	7.4E-03	2.1E-02		
Mercury	5.7E-03	1.6E-02	6.4E-03	1.8E-02	4.2E-03	1.2E-02	6.1E-03	1.7E-02	9.0E-03	2.5E-02	1.1E-02	3.0E-02		
Silver	1.7E-03	4.6E-03	1.9E-03	5.4E-03	1.5E-03	4.2E-03	2.2E-03	6.3E-03	2.0E-03	5.5E-03	2.7E-03	7.7E-03		
Thallium	2.3E-01	6.4E-01	2.7E-01	7.7E-01	1.9E-01	5.4E-01	2.0E-01	5.6E-01	2.3E-01	6.4E-01	2.2E-01	6.1E-01		
Total	*5E-01*	*1E+00*	*6E-01*	*2E+00*	*4E-01*	*1E+00*	*5E-01*	*1E+00*	*6E-01*	*2E+00*	*6E-01*	*2E+00*	*4E-02*	*1E-01*

Part B: Evaluation of Cancer Risk

Analyte	All Areas Avg	All Areas RME	Area 1 Avg	Area 1 RME	Area 2 Avg	Area 2 RME	Area 3 Avg	Area 3 RME	Area 4 Avg	Area 4 RME	Area 5 Avg	Area 5 RME	Area 6 Avg	Area 6 RME
Arsenic	8.9E-06	8.3E-05	1.0E-05	9.5E-05	8.3E-06	7.7E-05	1.1E-05	1.0E-04	1.2E-05	1.1E-04	1.2E-05	1.1E-04		
Total	*9E-06*	*8E-05*	*1E-05*	*1E-04*	*8E-06*	*8E-05*	*1E-05*	*1E-04*	*1E-05*	*1E-04*	*1E-05*	*1E-04*		

Blank cells indicate no data is available to evaluate risk
Shading indicates a value exceeding a level of concern (non-cancer: HI>1E+00; cancer: Risk>1E-04)

Table 4-6: Risk Estimates for Residential Consumption of Tap Water

Part A: Evaluation of Chronic Non-Cancer Risk

Analyte	All Areas	
	Avg	RME
Arsenic	1.8E-01	3.8E-01
Cadmium	1.2E-02	2.4E-02
Total	2E-01	4.0E-01

Part B: Evaluation of Cancer Risk

Analyte	All Areas	
	Avg	RME
Arsenic	1.1E-05	7.3E-05
Total	1E-05	7E-05

Table 4-7: Risk Estimates at Non-Residential Areas

<u>**RECREATIONAL USER**</u>

Part A: Evaluation of Chronic Non-Cancer Risk

Analyte	Area A Avg	Area A RME	Area B Avg	Area B RME	Area C Avg	Area C RME	Area D Avg	Area D RME	Area E Avg	Area E RME	Area F Avg	Area F RME	Area G Avg	Area G RME
Antimony	3E-01	1E+00			6E-02	3E-01	2E-01	8E-01	8E-01	4E+00	2E-01	9E-01		
Arsenic	1E+00	5E+00			1E+00	5E+00	2E+00	7E+00	2E+00	9E+00	2E+00	9E+00		
Cadmium	2E-01	8E-01			1E-01	6E-01	6E-02	3E-01	2E-01	7E-01	1E-01	5E-01		
Iron	1E-01	5E-01												
Manganese	2E-02	8E-02			2E-02	1E-01	9E-03	4E-02	4E-02	2E-01	2E-02	1E-01		
Mercury	2E-02	1E-01			2E-02	7E-02	5E-01	2E+00	2E-02	1E-01	4E-03	2E-02		
Silver	2E-02	1E-01			2E-02	1E-01	2E-02	8E-02	1E-02	6E-02	3E-02	1E-01		
Thallium	6E-01	3E+00			8E-01	4E+00	9E-02	4E-01	8E-01	4E+00	3E-01	1E+00		
Total	*2E+00*	*1E+01*			*2E+00*	*9E+00*	*2E+00*	*1E+01*	*4E+00*	*2E+01*	*3E+00*	*1E+01*		

Part B: Evaluation of Cancer Risk

Analyte	Area A Avg	Area A RME	Area B Avg	Area B RME	Area C Avg	Area C RME	Area D Avg	Area D RME	Area E Avg	Area E RME	Area F Avg	Area F RME	Area G Avg	Area G RME
Arsenic	5E-05	4E-04			4E-05	3E-04	6E-05	6E-04	8E-05	7E-04	8E-05	7E-04		
Total	*5E-05*	*4E-04*			*4E-05*	*3E-04*	*6E-05*	*6E-04*	*8E-05*	*7E-04*	*8E-05*	*7E-04*		

<u>**FUTURE RESIDENTIAL**</u>

Part A: Evaluation of Chronic Non-Cancer Risk

Analyte	Area A Avg	Area A RME	Area B Avg	Area B RME	Area C Avg	Area C RME	Area D Avg	Area D RME	Area E Avg	Area E RME	Area F Avg	Area F RME	Area G Avg	Area G RME
Antimony	2E-01	5E-01			4E-02	1E-01	1E-01	3E-01	6E-01	2E+00	1E-01	4E-01		
Arsenic	8E-01	2E+00			7E-01	2E+00	1E+00	3E+00	1E+00	4E+00	1E+00	4E+00		
Cadmium	1E-01	3E-01			9E-02	3E-01	4E-02	1E-01	1E-01	3E-01	8E-02	2E-01		
Iron	8E-02	2E-01												
Manganese	1E-02	4E-02			2E-02	5E-02	6E-03	2E-02	3E-02	8E-02	2E-02	5E-02		
Mercury	1E-02	4E-02			1E-02	3E-02	3E-01	9E-01	1E-02	4E-02	3E-03	8E-03		
Silver	2E-02	4E-02			2E-02	4E-02	1E-02	4E-02	9E-03	2E-02	2E-02	5E-02		
Thallium	4E-01	1E+00			5E-01	1E+00	6E-02	2E-01	6E-01	2E+00	2E-01	6E-01		
Total	*2E+00*	*5E+00*			*1E+00*	*4E+00*	*2E+00*	*5E+00*	*3E+00*	*8E+00*	*2E+00*	*5E+00*		

Part B: Evaluation of Cancer Risk

Analyte	Area A Avg	Area A RME	Area B Avg	Area B RME	Area C Avg	Area C RME	Area D Avg	Area D RME	Area E Avg	Area E RME	Area F Avg	Area F RME	Area G Avg	Area G RME
Arsenic	4.7E-05	4.4E-04			3.9E-05	3.7E-04	6.4E-05	5.9E-04	8.0E-05	7.4E-04	8.1E-05	7.6E-04		
Total	*5E-05*	*4E-04*			*4E-05*	*4E-04*	*6E-05*	*6E-04*	*8E-05*	*7E-04*	*8E-05*	*8E-04*		

Blank cells indicate no data is available to evaluate risk
Shading indicates a value exceeding a level of concern (non-cancer: HI>1E+00; cancer: Risk>1E-04)

Table 5-1: Summary Statistics for Lead in Surface Soils Collected From Non-Residential Areas

Area*	Count	Min (mg/kg)	Max (mg/kg)	Avg (mg/kg)
01	0	--	--	--
02	7	55	2,384	615
03	2	1,490	7,897	4,694
04	2	5,662	20,860	13,261
05	2	9,983	75,990	42,987
06	28	462	6,407	2,584
07	4	9,834	11,771	10,989
08	5	7,003	9,536	8,404
09	5	12,516	22,350	18,506
10	7	2,235	8,791	5,556
11	4	2,682	31,290	20,041
12	2	2,533	2,831	2,682
13	3	8,046	12,218	10,827
14	5	7,003	37,250	13,827
15	9	2,086	3,427	2,881
16	12	5,513	20,860	12,479
17	2	5,662	10,579	8,121
18	9	1,639	22,350	10,546
19	10	2,533	14,900	5,811
20	8	12,218	44,700	23,039
21	2	3,278	7,599	5,439
22	2	6,556	10,132	8,344
23	2	253	373	313
24	4	2,533	3,129	2,868
25	20	2,980	10,132	5,491

Based on adjusted XRF data set
* See Figure 2-4 for map location

Table 5-2: Relative Lead Mass of Mineral Phases for Test Materials Evaluated for In Vivo Bioavailibility

Phase	Aspen Residential	Aspen Berm	Bingham Creek Channel	Bingham Residential Composite	Butte Soil	California Gulch Phase I Res. Comp.	California Gulch Fe/Mn PbO	California Gulch AV Slag	California Gulch Oregon Gulch	Jasper High Pb Smelter	Jasper High Pb Mill	Jasper Low Pb Yard	Midvale Slag Composite	Murray Slag Composite	Murray Soil Composite	Palmerton Location 2	Palmerton Location 4	NIST Paint	Galena + Soil
Al-Pb Silicate	0%	0.1%			0.1%														
Anglesite	1%	7%	28%		36%	10%		2%		1%	2%	0%		1.0%		6%	4%	1%	
Cerussite	64%	62%	0.3%	2%	0.3%	20%		1%		32%	57%	81%	4%	1.1%	14%			55%	
Fe-Pb Oxide	7%	9%	2%	5%	7%	6%	8%	51%		3%	2%	1%	0.3%			2%	2%		
Fe-Pb Silicate			0.3%	1%							1%	0.04%							
Galena	17%	12%	9%		12%	2%		3%	100%		3%	8%	6%	9%	20%				100%
Mn-Pb Oxide	5%	4%	2%	18%	20.2%	22%	72%			2%	9%	2%		0.8%		66%	66%		
Pb Organic	0.03%	0.03%	0.3%			0.11%	0.11%	1%											
Pb-As Oxide			1%	2%				31%				0.17%	33%	6%	29%				
Pb Oxide										0.09%	7%			69%	27%			44%	
Pb Barite	0%	0.06%	0.0%		0.007%	0.15%	0.14%				0.01%					1%	0.1%		
Pb Phosphate	1%	1%	26%	50%	3.6%	30%	15%			21%	7%	6%				24%	1%		
Fe-Pb Sulfate	5%	5%	30%	22%	20%	6%	3%	0.3%		3%	1%	1%	0.1%	0.3%	0.6%	1%			
PbO-Cerrusite						1%													
Slag						1%		10%		4%	1%		16%	7%	6%				
Clay							0.01%			0.018%	0.017%	0.003%				0.03%	0.13%		
PbSiO4						2%	0.8%												
Lead Vanidate						0.1%	0.4%										18%		
Fe Silicate										11%	8%	1%		1.5%					
Calcite										0.2%	0.1%								
Native Lead										22%	2%		15%	0.7%					
Sulfosalts													0.4%						
Pb(M)O													26%	4%	3%		7%		
ZN(M)SIO4														0.03%					
As(M)O															0.003%				
FE														0.04%	0.13%				
Zn-Pb Silicate																	2%		
PbSiO4																	1%		
RBA	0.61	0.60	0.28	0.31	0.19	0.74	0.90	0.18	0.06	0.58	0.79	0.80	0.17	0.53	0.71	0.67	0.54	0.80	0.01

Table 5-3: Summary Statistics for the IEUBK Model
All Residential Properties

Area	Count	Min PbB	Max PbB	Avg PbB	GSD 1.6		GSD 1.4	
					Avg P10	P10>5	Avg P10	P10>5
1	218	6.1	46.6	14.8	69.2	100%	72.1	100%
2	93	5.1	25.3	11.3	53.2	100%	53.6	96%
3	6	5.1	27.7	14.4	56.5	100%	55.5	83%
4	116	5.5	42.7	17.6	77.3	100%	80.6	98%
5	61	5.9	43.2	16.5	74.6	100%	78.3	100%
6	11	6.9	33.9	16.6	74.4	100%	78.7	100%
Total	505	5.1	46.6	15.0	68.7	100%	71.3	99%

Table 5-4: IEUBK Results for Future Residential Children at Non-Residential Areas

Outside Area	Predicted PbB (ug/dL)	P10 (%)	
		GSD = 1.6	GSD = 1.4
1	--	--	--
2	8.0	32	26
3	24.2	97	100
4	42.7	100	100
5	81.5	100	100
6	17.1	87	94
7	38.6	100	100
8	33.4	99	100
9	51.0	100	100
10	26.6	98	100
11	53.3	100	100
12	17.5	88	95
13	38.3	100	100
14	43.6	100	100
15	18.2	90	96
16	41.3	100	100
17	32.8	99	100
18	37.7	100	100
19	27.2	98	100
20	57.5	100	100
21	26.2	98	100
22	33.2	99	100
23	6.3	16	8
24	18.2	90	96
25	26.4	98	100
Avg	33.4	91.3	92.3

-- No conc data available

I:\Eureka\Risk Calcs\Outside\Outside Lead Summary v2.xls

Table 5-5: Bower's Model Predictions for Recreational Visitors

Area #	Avg Surface Soil Concentration (mg/kg)	GM PbB (ug/dL)	95th Percentile PbB (ug/dL) GSD = 1.8
01	--	--	--
02	615	3.5	9.1
03	4,694	12.6	33.2
04	13,261	31.8	84
05	42,987	98.4	259
06	2,584	7.9	20.7
07	10,989	26.7	70
08	8,404	20.9	55.0
09	18,506	43.6	115
10	5,556	14.5	38.2
11	20,041	47.0	124
12	2,682	8.1	21.3
13	10,827	26.4	69.3
14	13,827	33.1	87
15	2,881	8.6	22.5
16	12,479	30.1	79
17	8,121	20.3	53.4
18	10,546	25.7	67.6
19	5,811	15.1	39.8
20	23,039	53.7	141
21	5,439	14.3	37.6
22	8,344	20.8	54.7
23	313	2.8	7.4
24	2,868	8.5	22.4
25	5,491	14.4	37.9
All	10,013	24.5	64.5

Table 5-6: Blood Lead Summary Statistics

Age	EUREKA						NHANES*	
	N	GM	MIN	MAX	N>10	% > 10	GM	% > 10
<1	3	5.0	3	9.5	0	0.0	--	--
1-2	17	9.1	2.5	18.5	8	47.1	4.1	11.5
3-5	31	7.2	1.6	32.2	10	32.3	3.4	7.3
6-11	50	6.6	1.8	42.4	13	26.0	2.5	4.0
12-19	32	3.1	0.9	21	2	6.3	1.6	1.6
20-49	65	2.6	0.9	35.1	1	1.5	2.6	3.3
50-69	20	3.9	0.9	12.7	1	5.0	4	7.0
$\geq$ 70	5	2.8	1.2	6.7	0	0.0	4	6.3
ALL	227	4.4	0.9	42.4	35	15.4	2.8	4.5

* Brody et al., 1994; Pirkle et al., 1994

Table 5-7: Summary of Survey Parameter Significance Testing

Survey Question	Response Category	N	Geomean PbB	p value	Correlation
Demographics					
Gender	M	19	6.5	0.0570	
	F	28	7.9		
Housing					
Peeling, chipping or flaking paint in dwelling?	None	19	6.7	0.2064	
	Any [1]	26	7.0		
Yard type	Bare Soil [2]	20	6.5	0.9387	
	Lawn	13	5.9		
Is there any peeling or chipping paint in the child's home?	No	30	7.3	0.6606	
	Yes	15	7.3		
Has the dwelling been remodeled or repainted in the last three months?	No	43	7.0	0.3257	
	Yes [3]	4	12.2		
Child Behavior					
Eats dirt or any other non-food item?	No	22	6.7	0.1465	
	Yes	24	8.1		
Chews on toys or crayons?	No	16	6.6	0.1367	
	Yes	31	7.7		
Uses any foreign crayons manufactured outside the US?	No	32	7.2	0.7385	
	Yes	5	8.7		
Pick at or play near chipping or flaking paint?	No	33	7.5	0.6373	
	Yes	10	7.2		
Pick at or play near areas of broken plaster?	No	34	8.3	0.1518	
	Yes	7	5.5		
Place paint chips or broken plaster in mouth?	No	3	12.0	0.4659	
	Yes	37	6.6		
Place fingers in mouth?	No	3	9.5	0.2569	
	Yes	43	9.9		
Chew on Furniture, crib, or window sills?	No	17	7.2	0.7074	
	Yes	26	7.5		
Parents/Guardians/Family Members					
Battery Work? (during last six months)	No	41	7	0.0055	positive
	Yes	2	12		
Radiator Repair? (during last six months)	No	40	6.9	0.2179	
	Yes	5	10.1		
Auto Repair? (during last six months)	No	34	7	0.1238	
	Yes	12	10		
Auto Body Work? (during last six months)	No	44	7.2	NA	
	Yes	1	11		
Metal Working? (during last six months)	No	36	7.8	0.1585	
	Yes	9	5.6		
Welding? (during last six months)	No	35	7.4	0.6131	
	Yes	10	7.0		
Foundry working? (during last six months)	No	45	7.2	NA	
	Yes	1	11.4		
Mining? (during last six months)	No	45	7.2	NA	
	Yes	1	11.4		

Survey Question	Response Category	N	Geomean PbB	p value	Correlation
Sandblasting? (during last six months)	No	44	7.1	0.2520	
	Yes	2	11.3		
Plumbing? (during last six months)	No	45	7.2	NA	
	Yes	1	4.2		
Painting? (during last six months)	No	42	7.4	0.0688	
	Yes	3	5.2		
Household Activities: Ceramic Painting?	No	45	7.6	0.0001	negative
	Yes	2	3.5		
Household Activities: Auto Body Repair?	No	44	7.3	0.8257	
	Yes	3	6.8		
Household Activities: Radiator repair?	No	43	7.1	0.6969	
	Yes	3	9.0		
Household Activities: Painting bicycles or furniture?	No	46	7.2	NA	
	Yes	1	11		
Household Activities: Refinish furniture?	No	46	7.2	NA	
	Yes	1	11		
Household Activities: Make black powder shots?	No	43	7.6	0.1804	
	Yes	4	4.9		
Tobacco Use	No	12	5.0	0.0079	positive
	Yes	34	8.3		
Parent Education Level	some highschool	8	6.0	0.6834	
	highschool/GED or greater	156	4.1		
Parent Education Level	some high school or high school diploma/GED	112	4.3	0.9126	
	Higher education (Jr college/ 4-year college/masters)	52	4.0		
Child Medical History: symptoms more than 4 times in last 3 months?					
Vomiting	No	41	7.2	0.6629	
	Yes	6	8.4		
Nausea	No	40	7.2	0.8111	
	Yes	5	8.2		
Weight Loss	No	44	7.1	0.0113	positive
	Yes	2	12.0		
Loss of appetite	No	40	7.2	0.7202	
	Yes	7	8.2		
Stomach aches	No	39	7.5	0.2053	
	Yes	8	6.6		
Constipation	No	43	7.0	0.0027	positive
	Yes	4	12.4		
Extreme weakness or fatigue	No	45	7.4	NA	
	Yes	1	12.7		
Joint Pain	No	43	7	0.9798	
	Yes	3	8		
Headaches	No	45	7.4	NA	
	Yes	1	12.7		
Irritability	No	39	7.3	0.8581	
	Yes	7	8.1		
Trouble sleeping	No	43	7.0	0.0271	positive
	Yes	4	11.4		

Survey Question	Response Category	N	Geomean PbB	p value	Correlation
Youth Activity Survey Questions					
How often (a week) do your children ride bicycles, ATVs, motorcycles, etc. around town?	None	5	13.1	0.1684	
	1-5+ times	21	7.9		
How often (a week) do your children ride bicycles, ATVs, motorcycles, etc. around town?	1-2 times	5	5.4	0.1897	
	3 or more	16	8.9		
Average time spent each time riding bikes ect. .?	1-2 hours	12	9.3	0.3169	
	3 or more	9	6.6		
Do your children ride their bikes or play on the tailings piles?	No	22	9.2	0.0001	negative
	Yes	2	3.4		

Sources:

UDOH Childhood Lead Prevention Program. Environmental Evaluation and Child Risk Surveys. September/October 2000.

UDOH Youth Recreational Activity Survey at Eureka Mills, Eureka, Utah.

Notes:

Shaded cells indicate a correlation

Individuals with "not sure" responses or with no response were not included in the respective question's analysis

[1] Includes survey responses of Interior, Exterior or both Interior and Exterior Paint

[2] Includes 15-bare soil responses and 4-Partial soil responses.

   5 properties were excluded from this analysis that answered "Lawn and Bare soil or partial soil"

[3] Includes indoor, outdoor or both indoor and outdoor remodeling

Table 5-8: Observed and Predicted Blood Lead in Children

Area	Children Tested	Children with PbB>10	Avg PbB ug/dL	Predicted Avg PbB ug/dL	GSD 1.6		GSD 1.4	
					Avg P10 (%)	P10>5	Avg P10 (%)	P10>5
1	33	12	8.8	12.2	59.6	94%	61.7	94%
2	15	5	10.6	8.2	32.7	93%	29.6	80%
3	0	--	--	--	--	--	--	--
4	6	1	7.2	10.9	49.0	100%	48.8	100%
5	5	2	8.0	9.2	42.9	100%	42.4	80%
6	0	--	--	--	--	--	--	--
Total	59	20	9.1	10.8	50.3	95%	50.6	90%

-- No data available

FIGURES

Figure 1-1
Eureka Site Location

Wyoming

Salt Lake City

Provo

Eureka

Colorado

Utah

N
W E
S
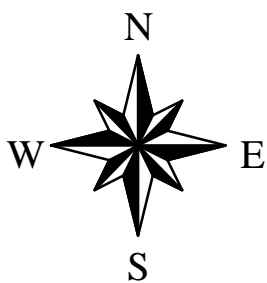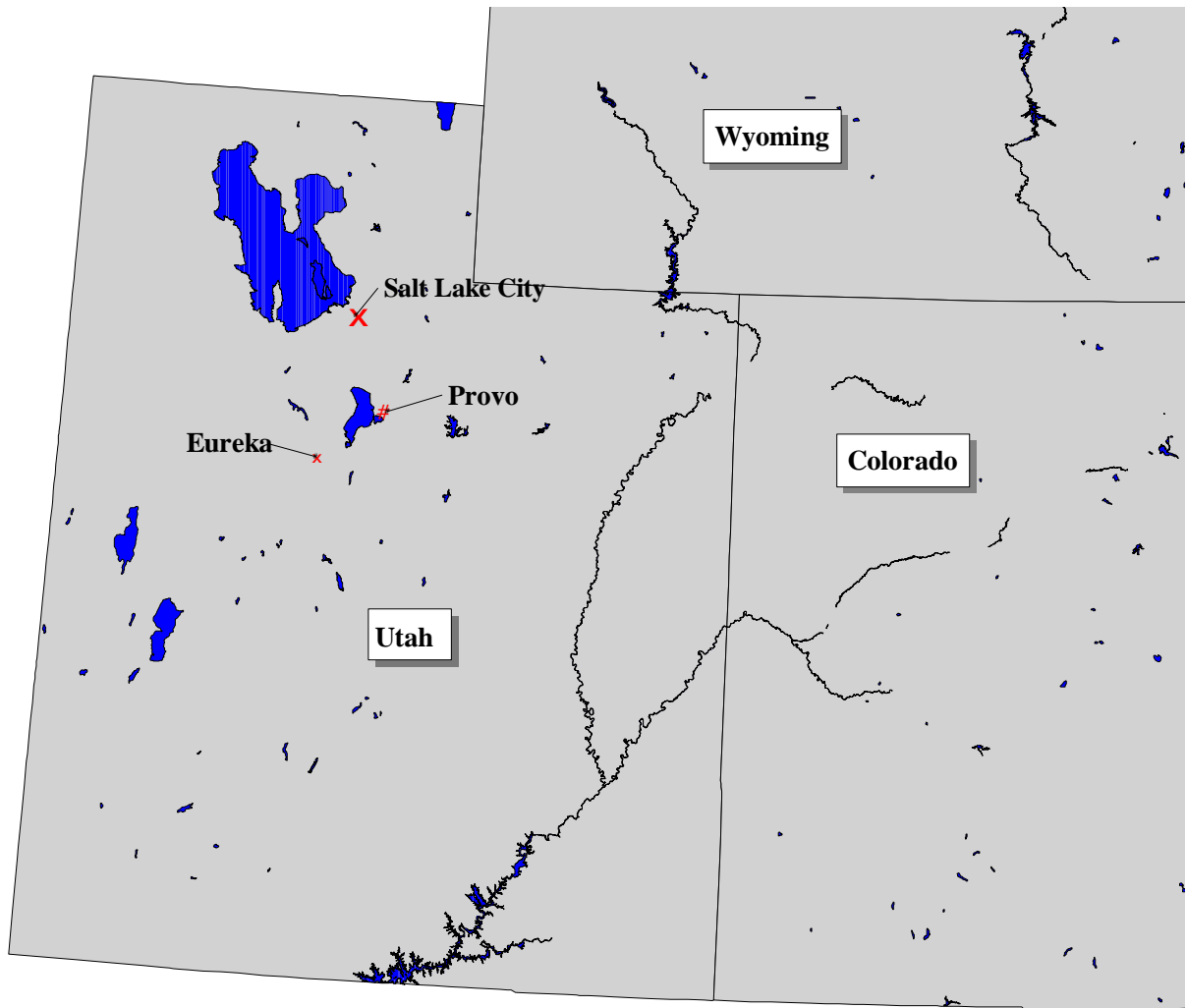
Figure 2-1
Eureka Mills Sample Locations

Outskirts sampling points
▲ XRF & ICP
▲ XRF
Town sampling points
● XRF & ICP
● XRF
Non-Residential Areas

Exposure Area 1

Exposure Area 2

Exposure Area 3

Exposure Area 6

Exposure Area 5
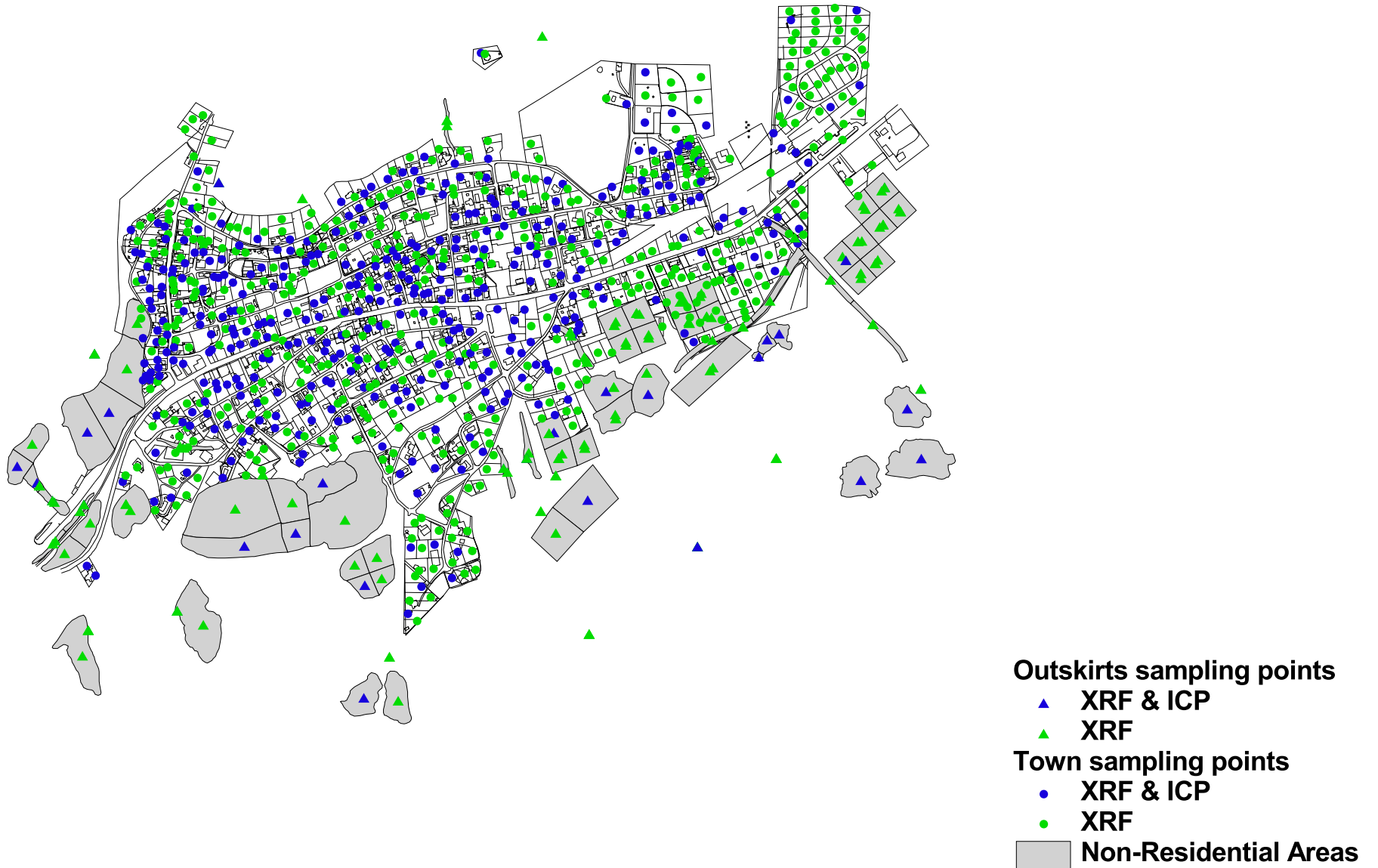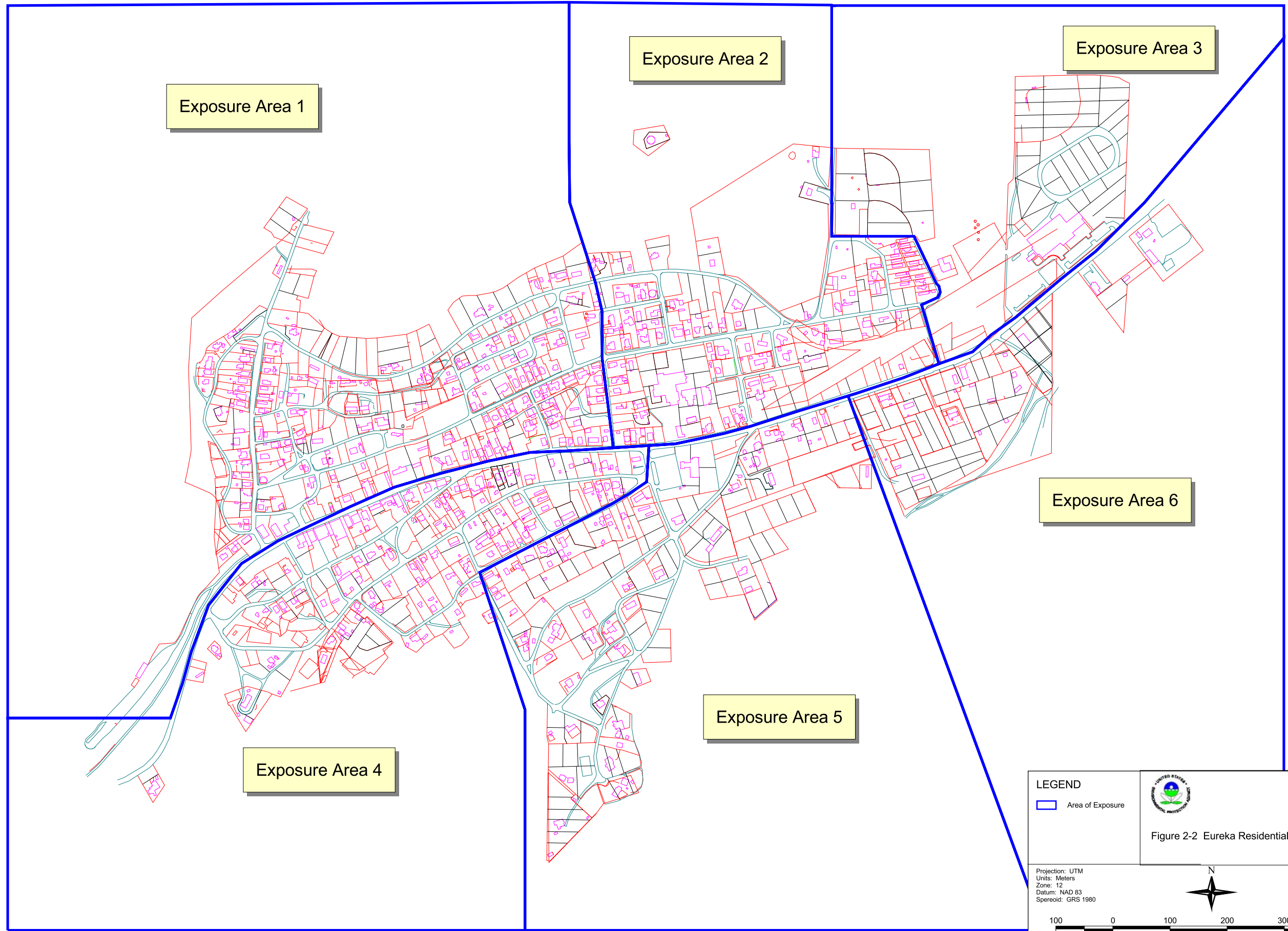
Exposure Area 4

LEGEND

Area of Exposure

Figure 2-2 Eureka Residential Exposure Areas

Projection: UTM
Units: Meters
Zone: 12
Datum: NAD 83
Spereoid: GRS 1980

N

100   0   100   200   300   400   Meters

Figure 2-3 Eureka Mine Waste Areas
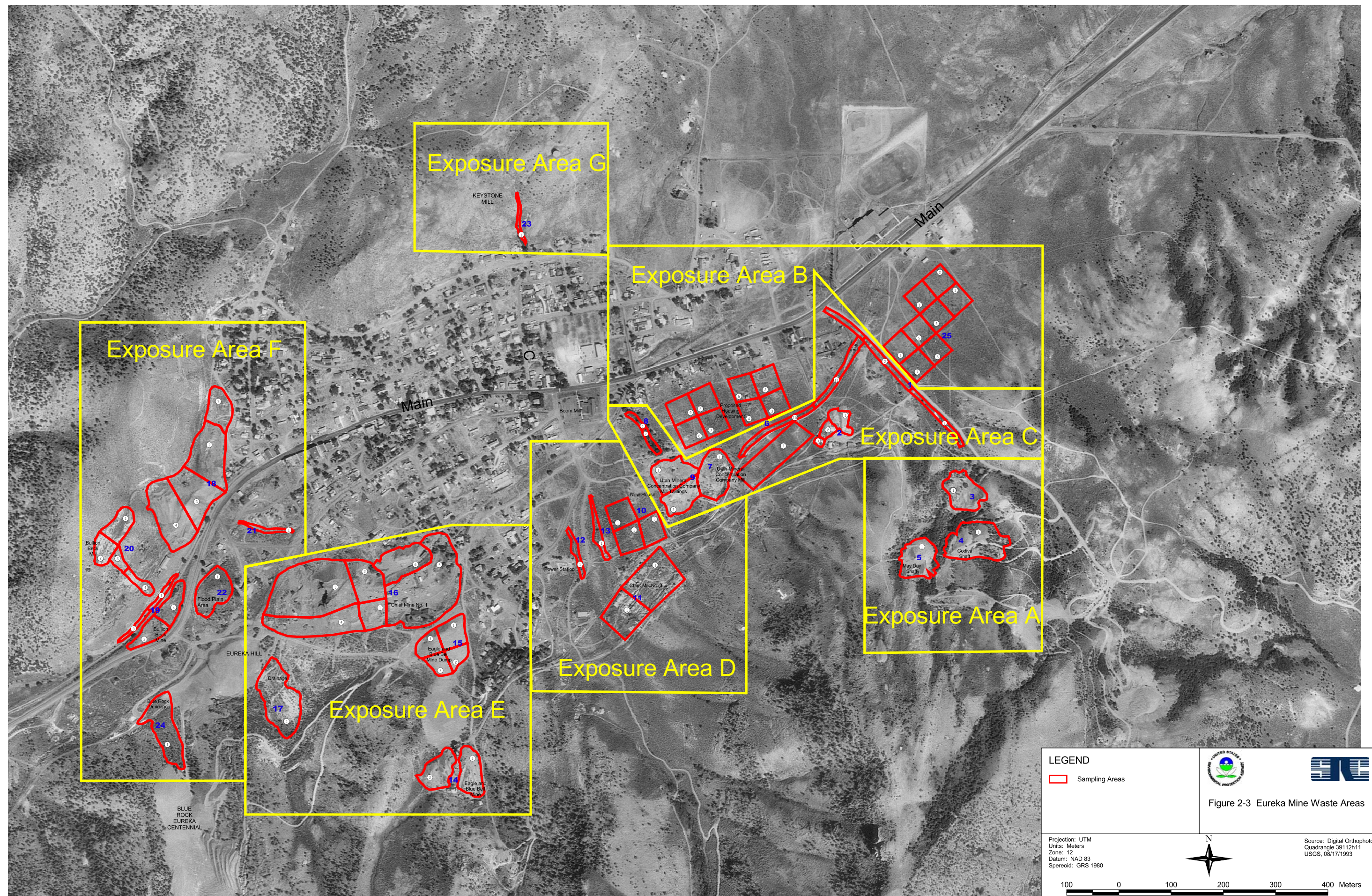
Figure 2-4
Sampling Locations for Speciation Analysis

Figure 2-5: Distribution of Arsenic Mass by Phase

Concentration of Arsenic in Each Phase (ppm)

900
800
700
600
500
400
300
200
100
0

Total Arsenic Concentration (ppm)

650
363
148
3

Phase

ZnSiO4
Fe Sulfate
Slag
Pyrite
Phosphate
PbSiO4
PbO
PbMO
PbAsO
Organics
Mn Oxide
Galena
Fe AsO
Fe Oxide
Cerussite
Calcite
Barite
AsMO
Anglesite
Clays

■ 0-100 ■ 100-200 □ 200-300 □ 300-400 ■ 400-500 ■ 500-600 ■ 600-700 □ 700-800 ■ 800-900

Eureka\ Speciation\ 3D Graphs-frozen\ Eureka_AsMass.xls

Figure 2-6: Distribution of Lead Mass by Phase

Eureka\ Speciation\ 3D Graphs-frozen\ Eureka_PbMass.xls
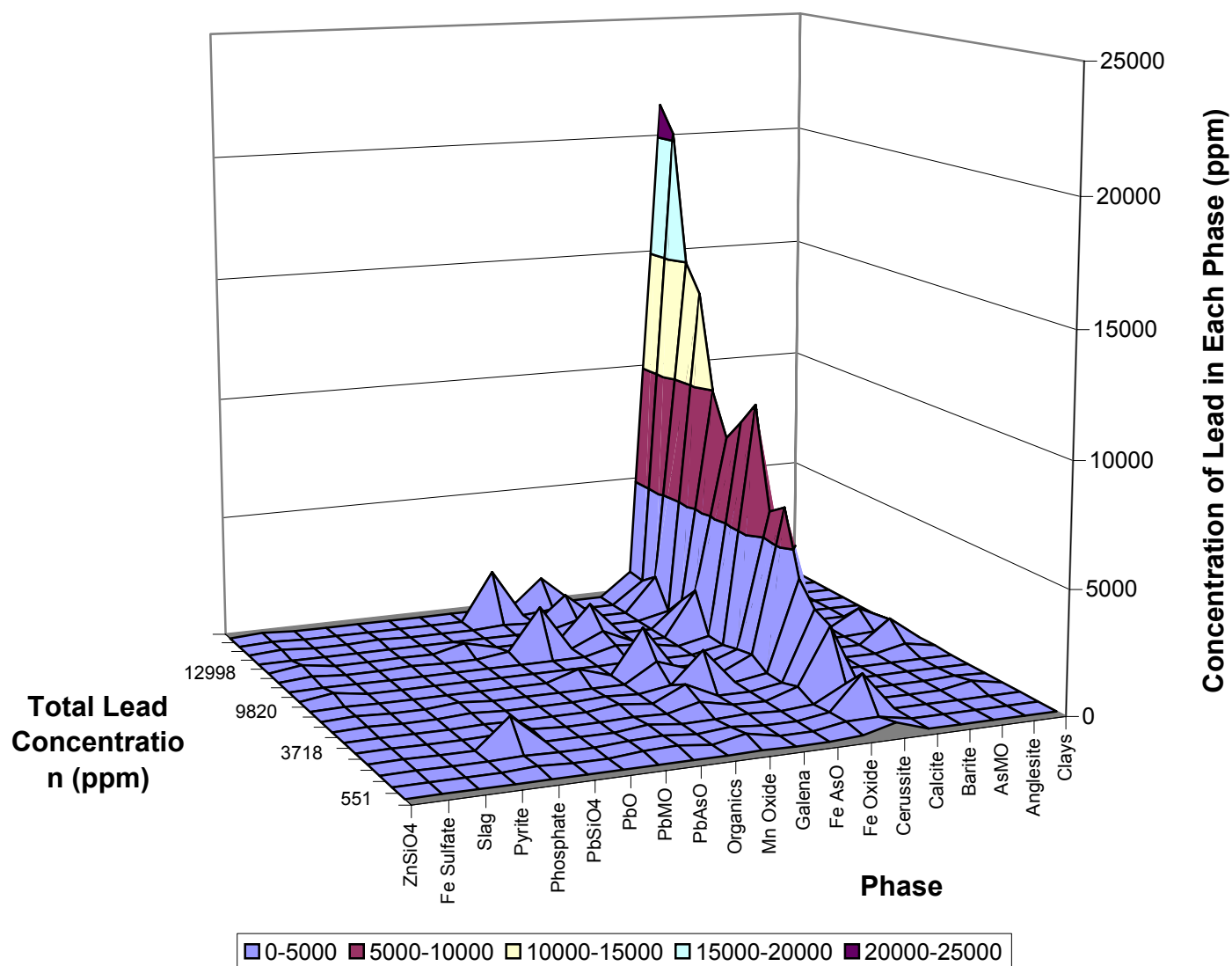
Figure 3-1: Conceptual Site Model for Residential Exposure to COPCs

| Historic Source | Primary Source | Transport Pathways | Contaminated Media | Exposure Route | Exposed Population |

Legend:
- (hatched circle) Pathway is or may be complete; however, risk is low or data are lacking; Qualitative Evaluation only.
- (filled circle) Pathway is or may be complete; and may be significant; Quantitative Evaluation.
- (open circle) Pathway is not complete; No Evaluation.

Exposed Population: Resident Child | Resident Adult | Rec. User

Indoor Dust → ORAL / DERMAL

Wind, Physical Transfer

Outdoor Soil → ORAL / DERMAL

Historic Airborne Releases

Hauling, Grading, Runoff, Wind

Vegetables → ORAL

Mining → **Discrete Waste Piles**

Direct Contact → ORAL / DERMAL

Wind Erosion → **Air** → INHALATION

Figure 3-2: Residential Soils Depth Profile for Lead
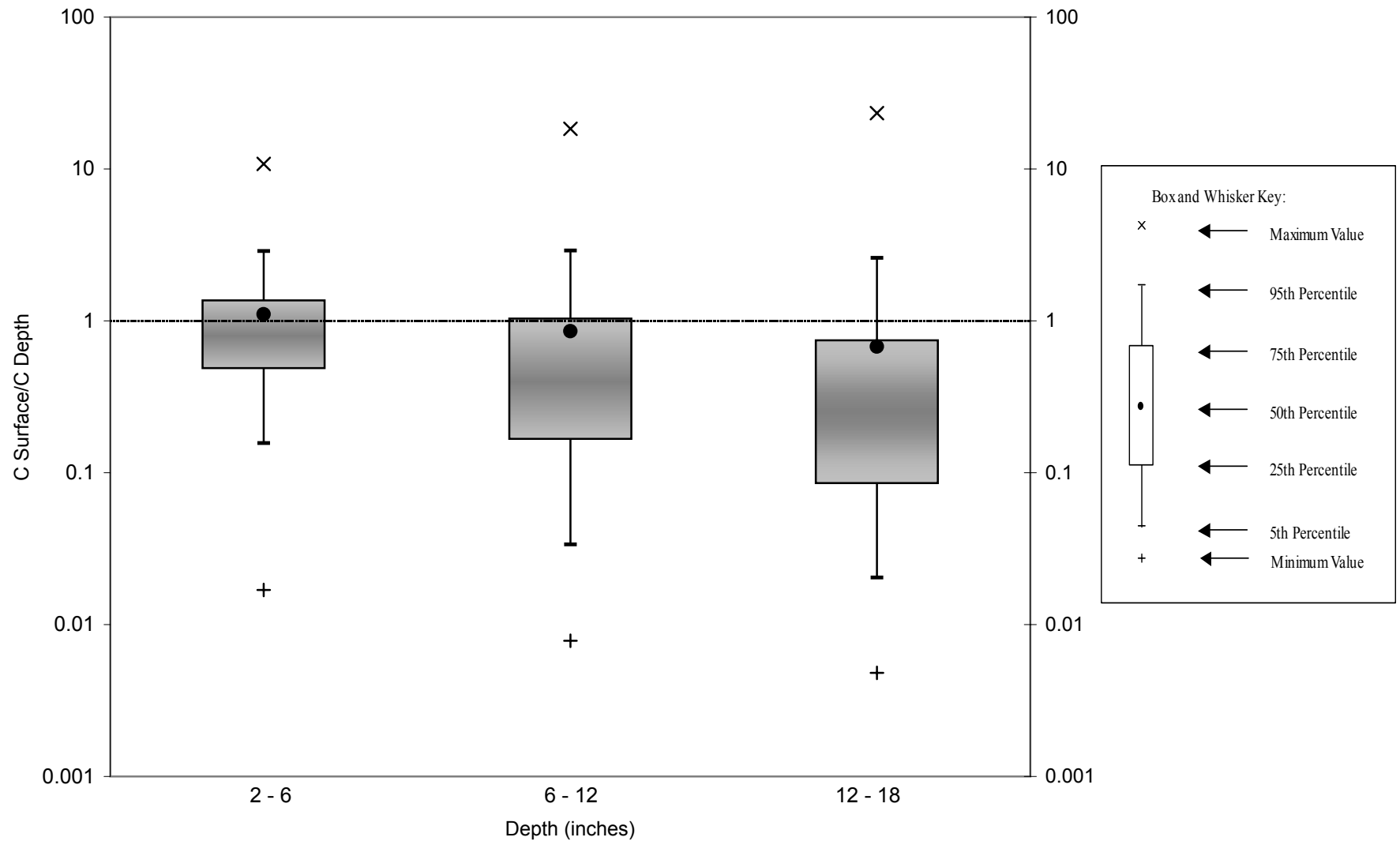
Figure 4-1: Risk Estimates for Residential Areas

Non-cancer Risk in Residential Areas

Cancer Risk in Residential Areas
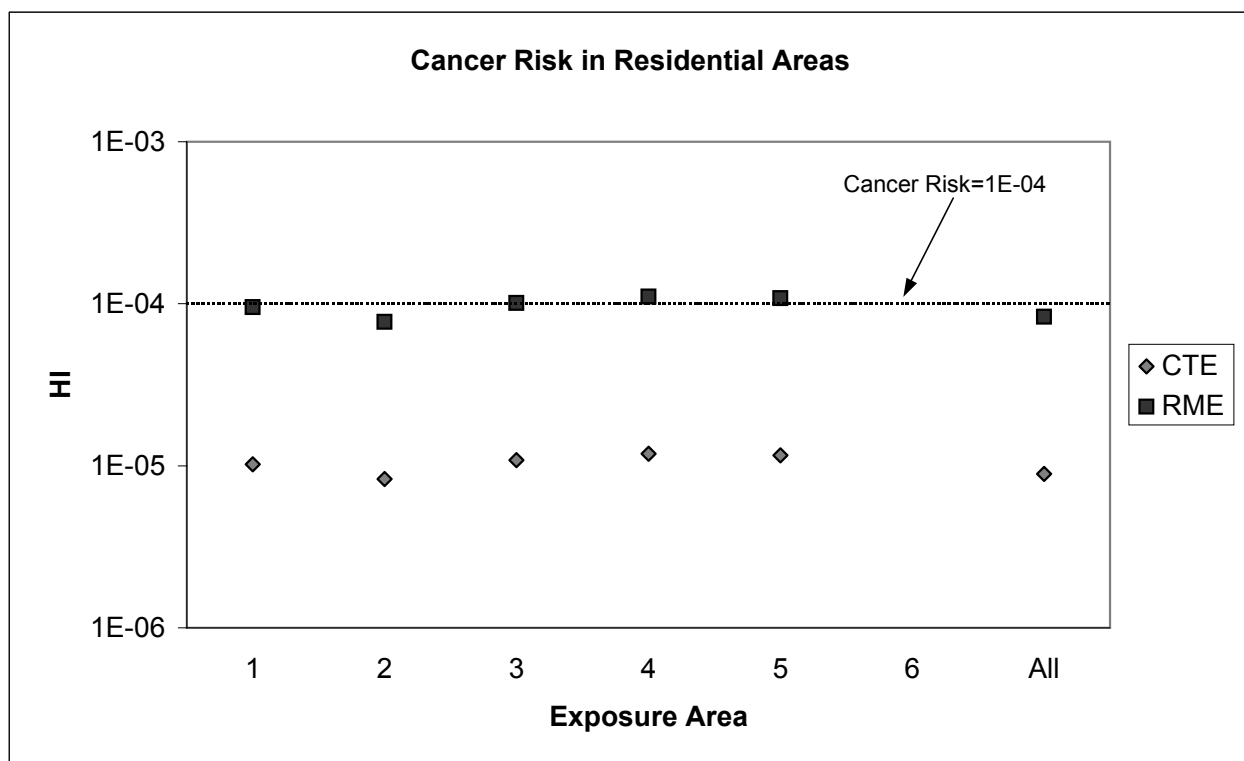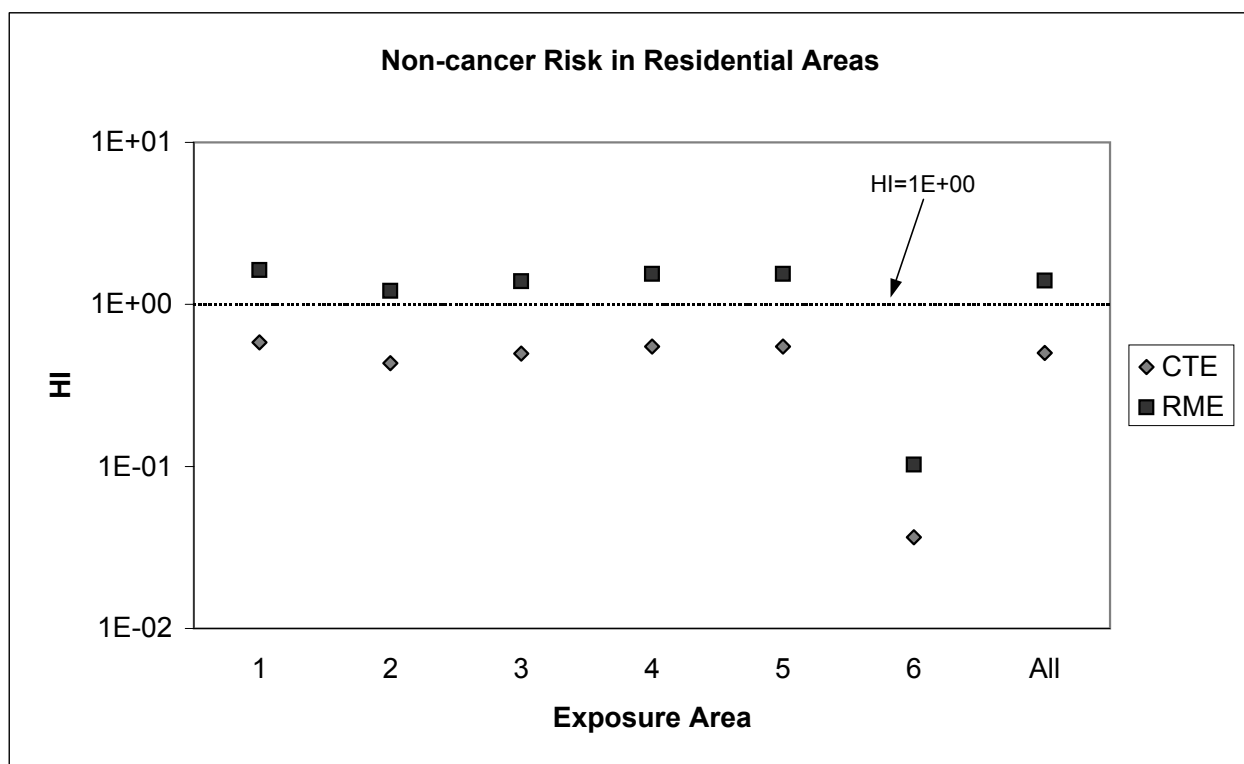
Figure 4-2: Risk Estimates for Recreational Users at Non-Residential Areas

Non-cancer Risk to Recreational Users at Non-Residential Areas

Cancer Risk to Recreational Users at Non-Residential Areas
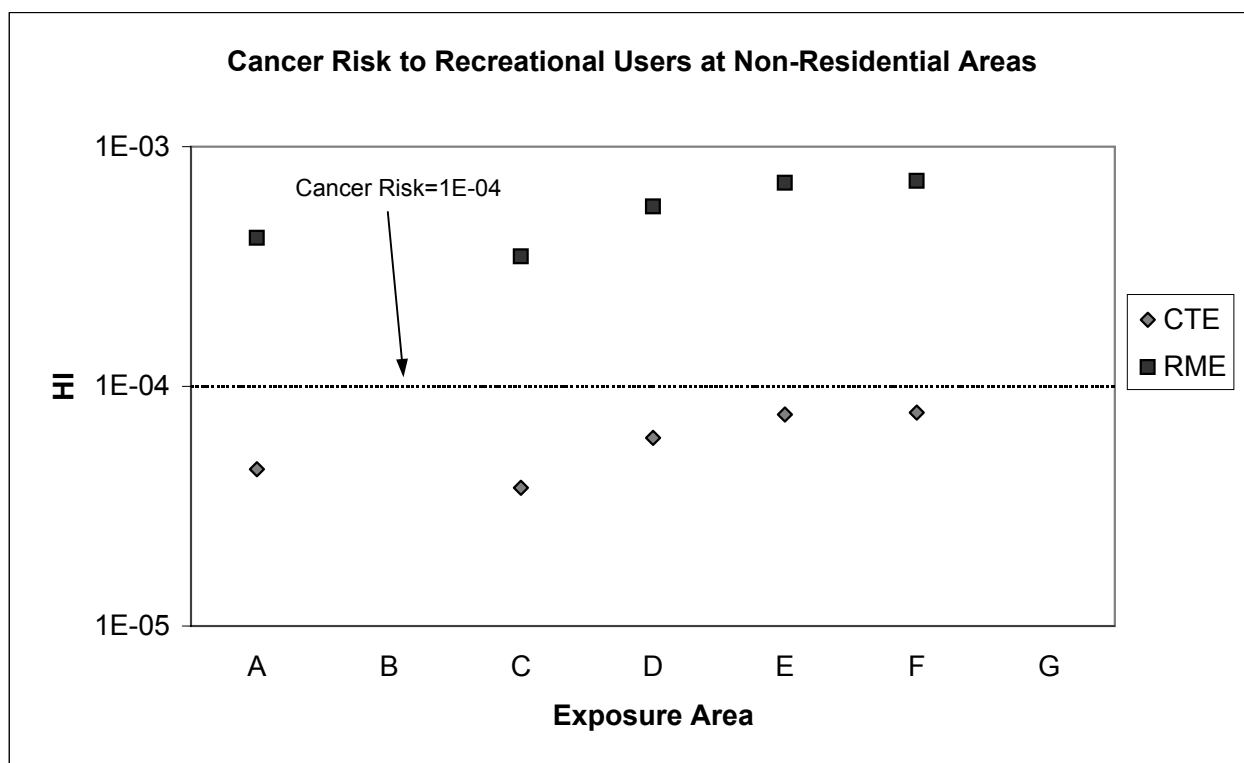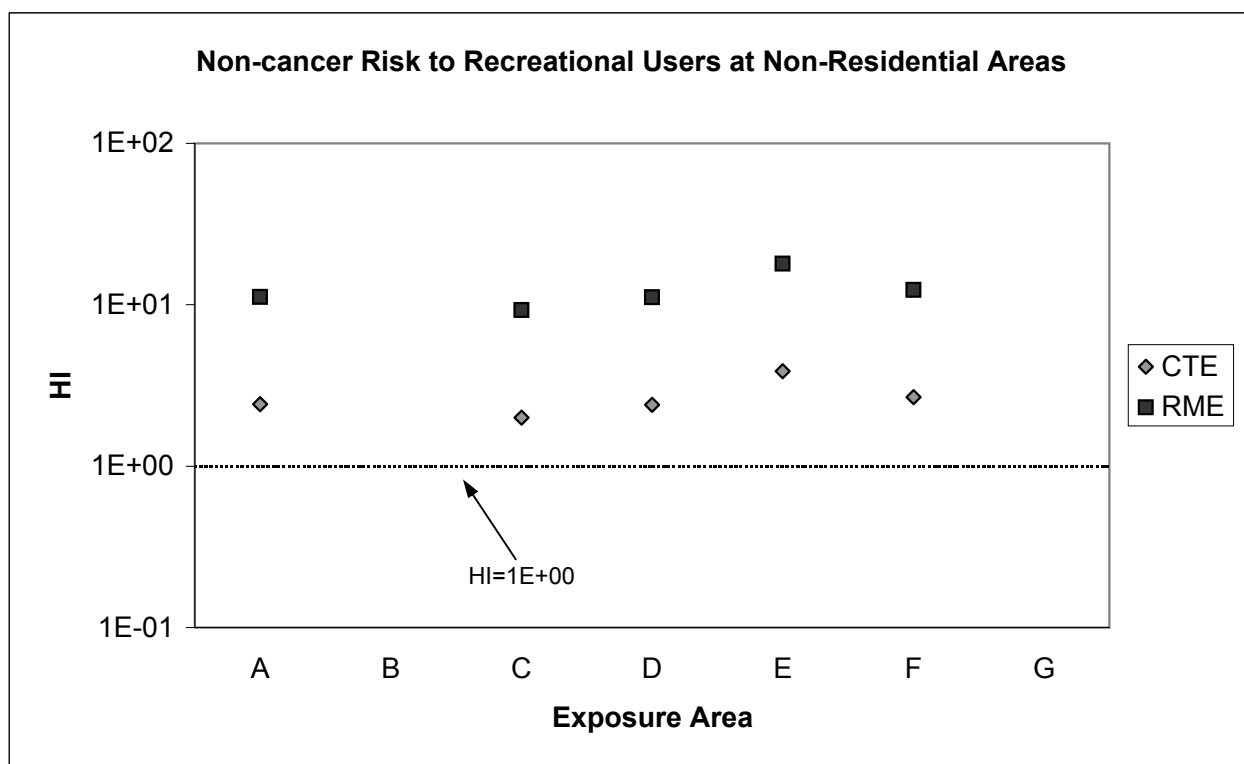
Figure 4-3: Risk Estimates for Future Residents at Non-Residential Areas

Non-cancer Risk to Future Residents at Non-Residential Areas

Cancer Risk to Future Residents at Non-Residential Areas
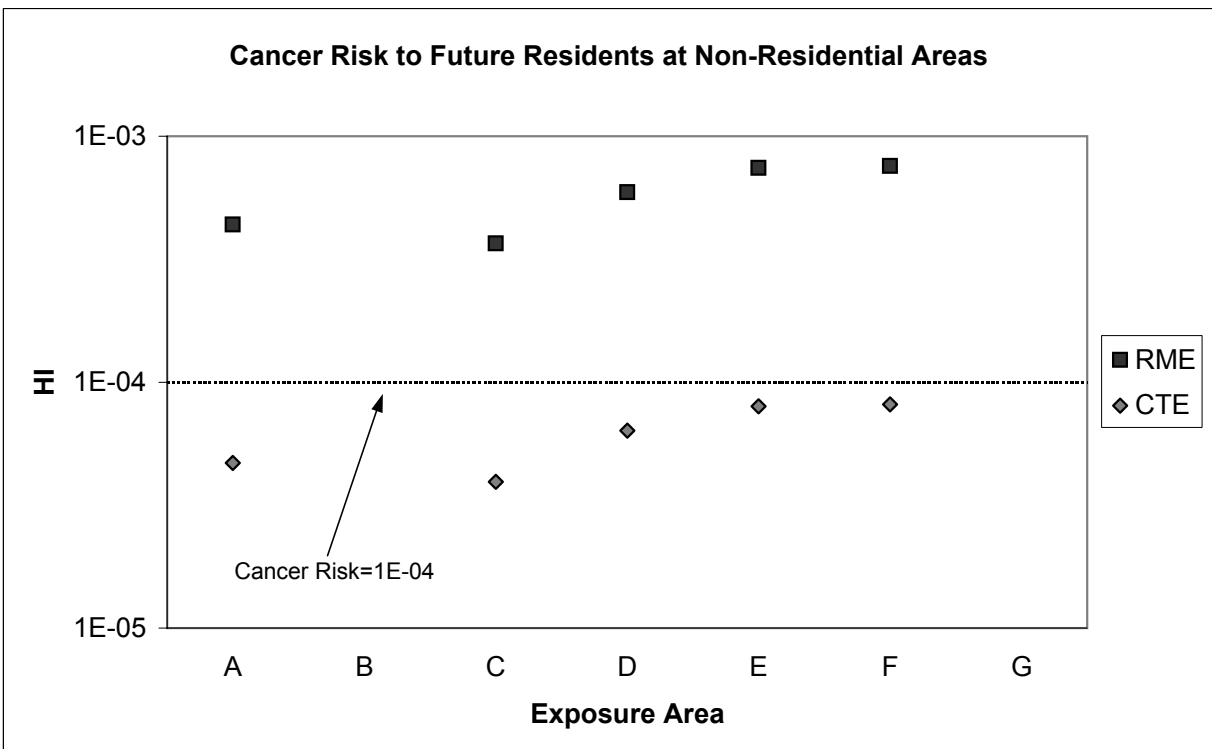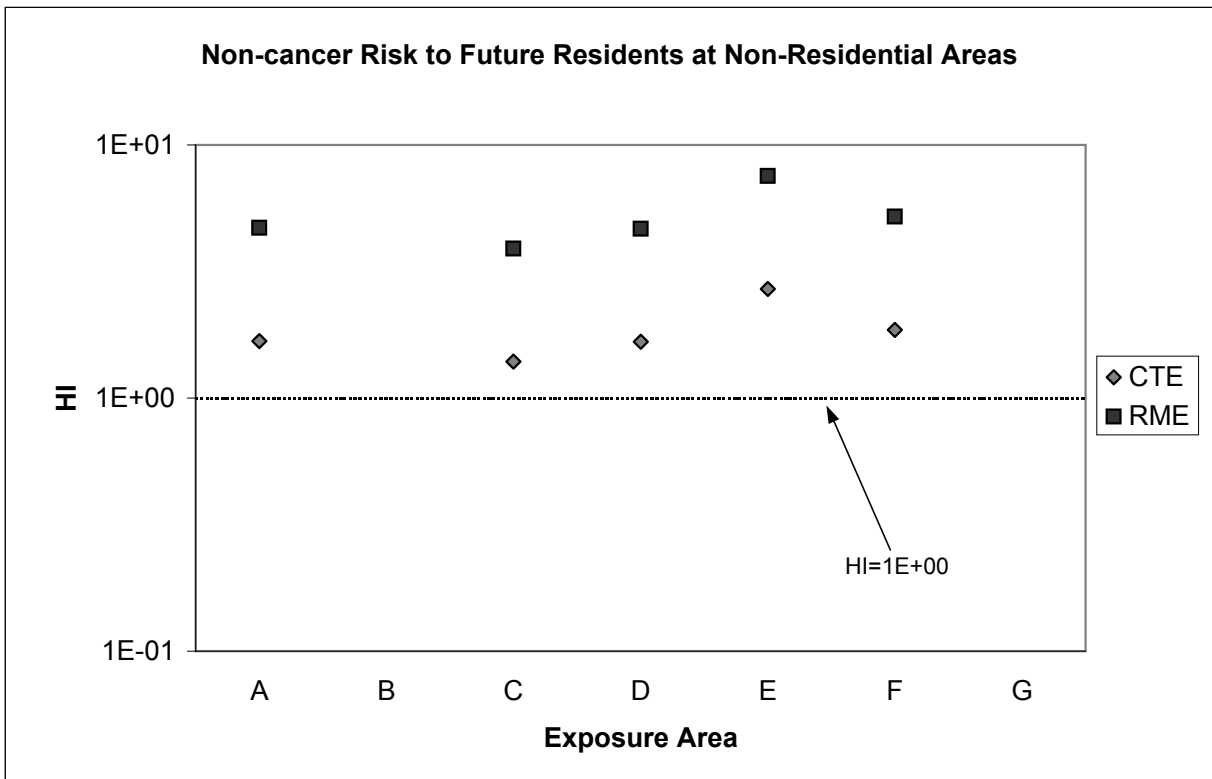
Figure 5-1: Lead Comparison Between ICP and XRF Analysis

$y = 1.4907x$

$R^2 = 0.9416$

I:\Eureka\Final Data\Graphs\XRF vs Confirmation Residential All Chemicals No Uxls.xls
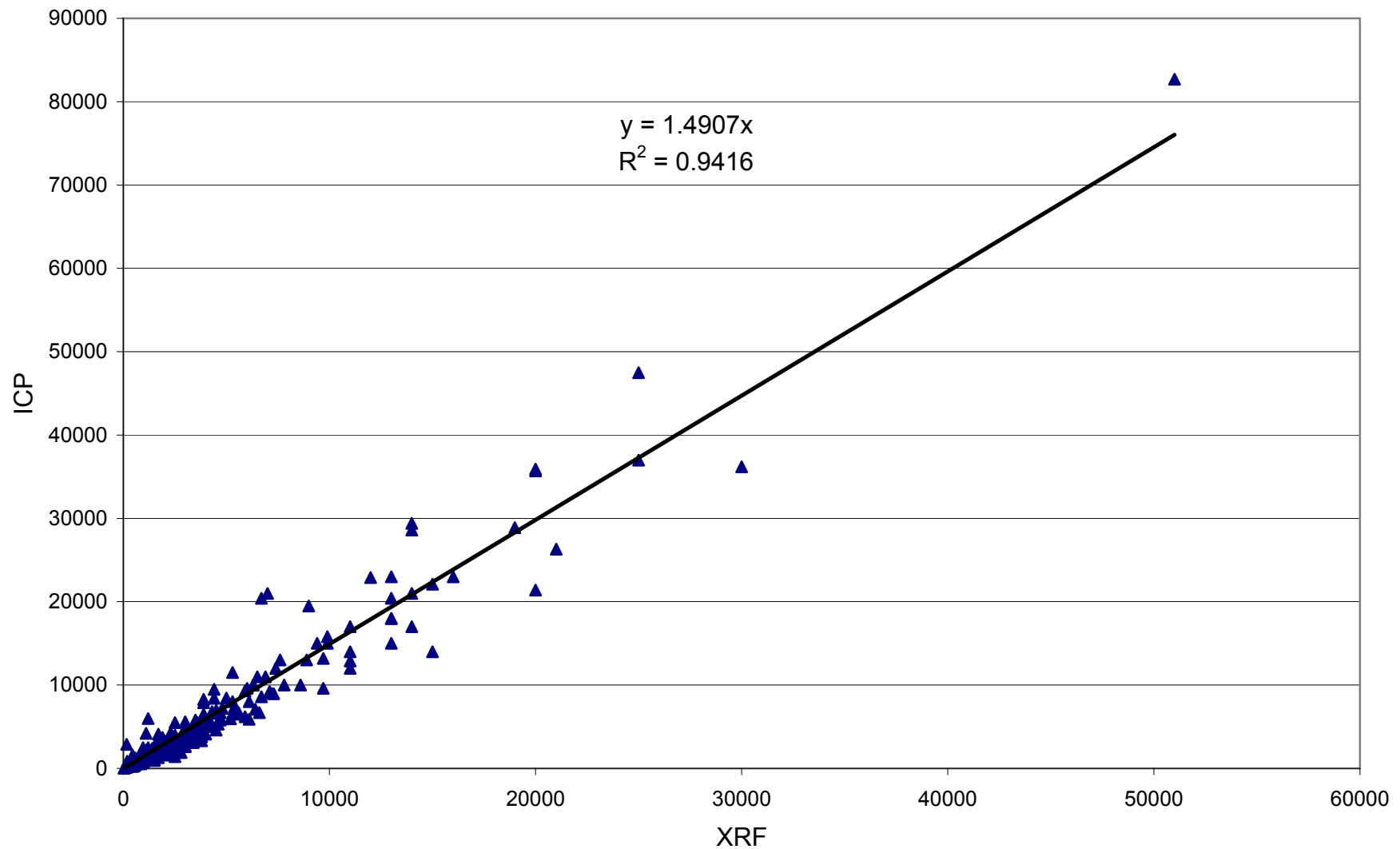
Figure 5-2: Site-Specific Soil-Dust Relationship for Lead

$y = 0.1537x + 457.86$
$R^2 = 0.2294$

Dust

Soil
(non detects removed, 0 intercept adjustment)

I:\Eureka\Final Data\Graphs\SoilDustRelationship.xls
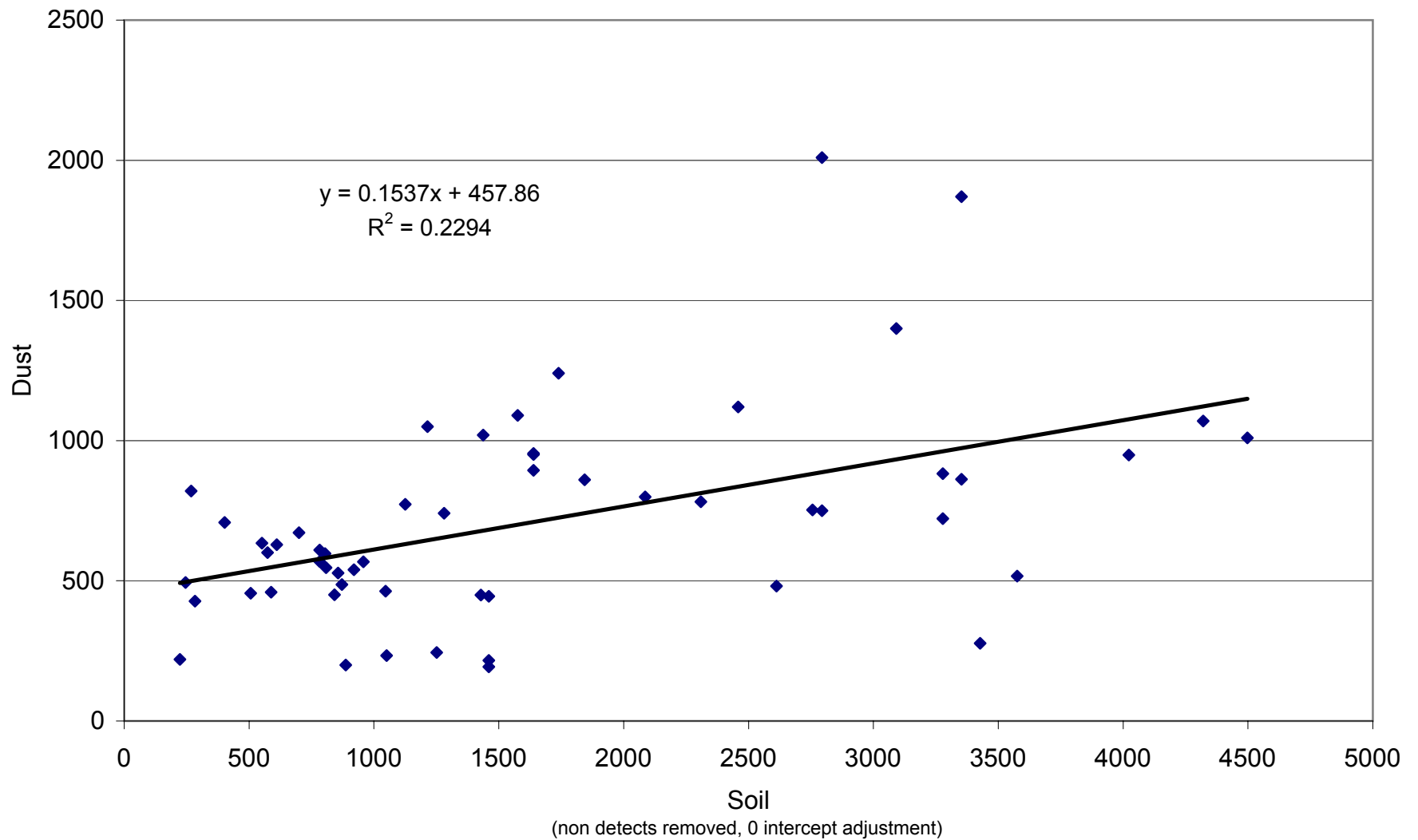
Figure 5-3: Summary Statistics for Predicted Residential Blood Leads
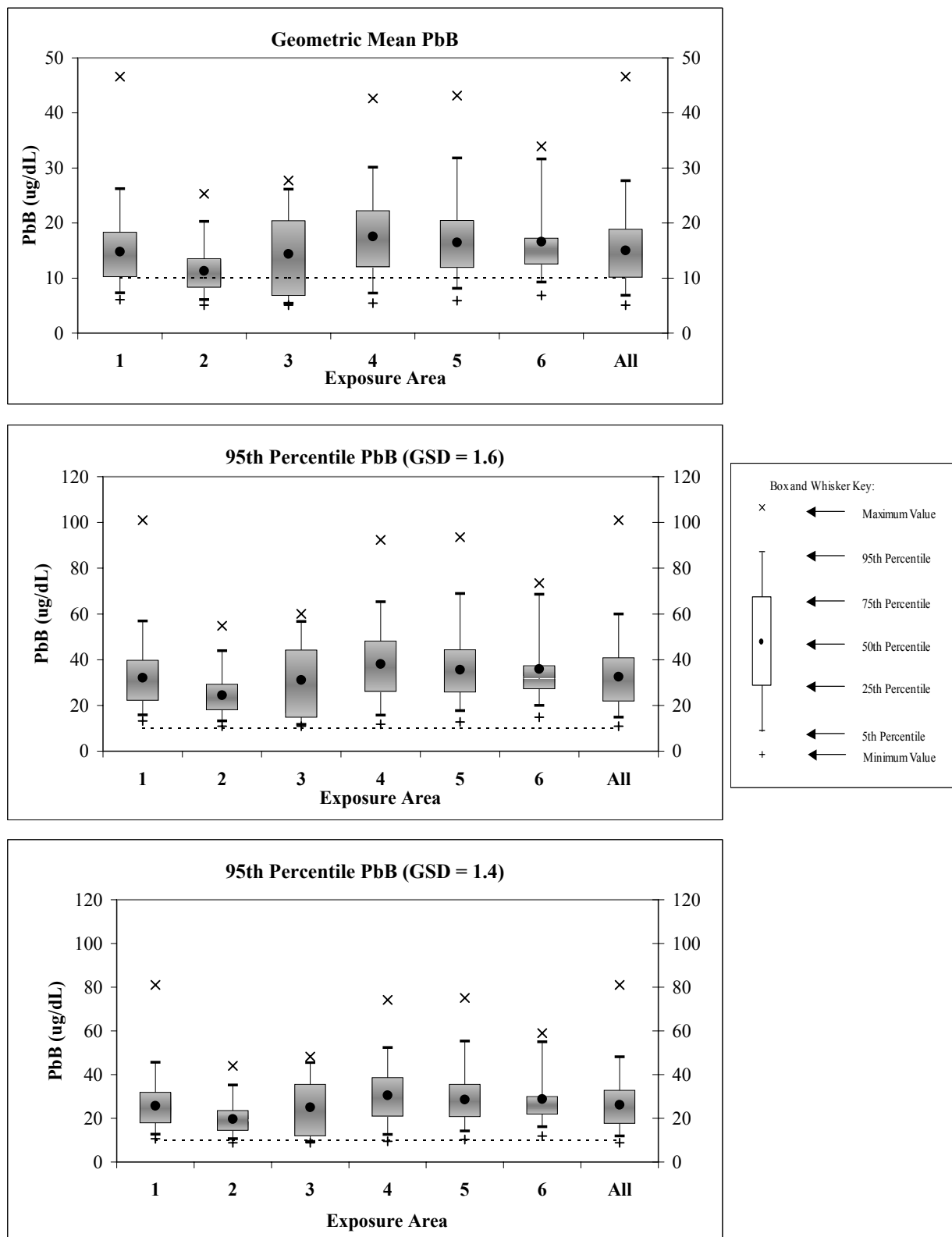
Figure 5-4: Blood Lead versus Soil Lead Concentrations

Soil Concentration vs. PbB
All Consenting Individuals

Soil Concentration vs. PbB
Consenting Children (0-6)
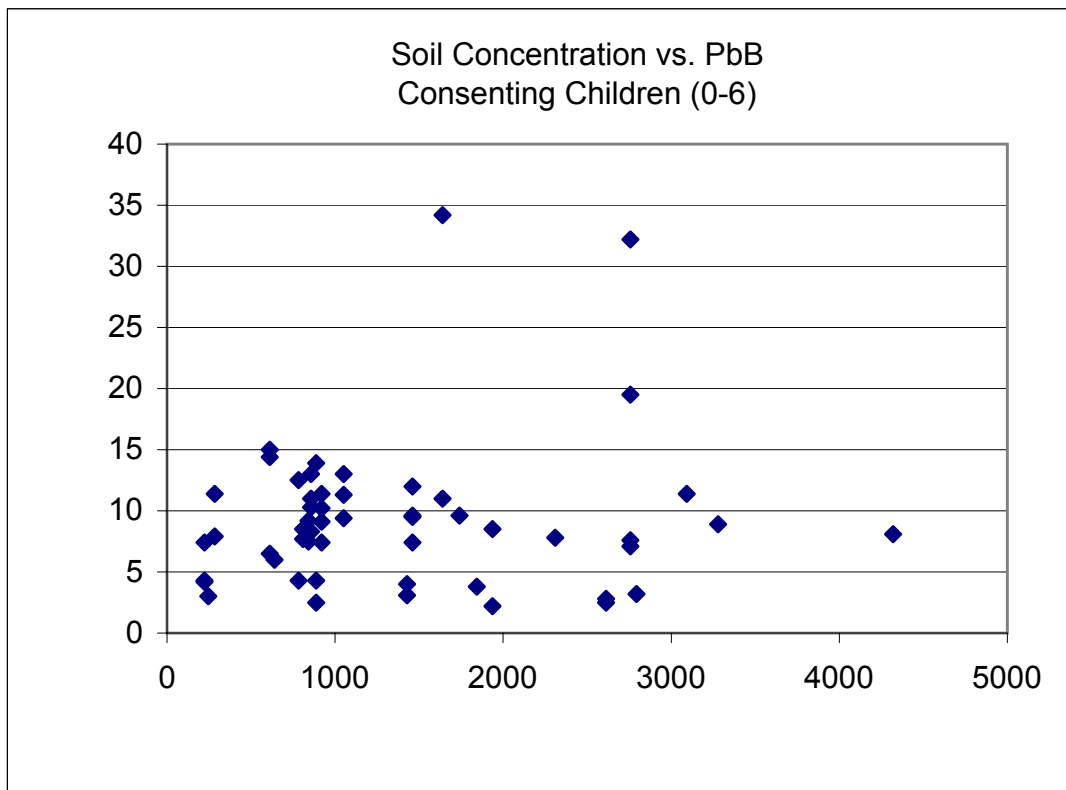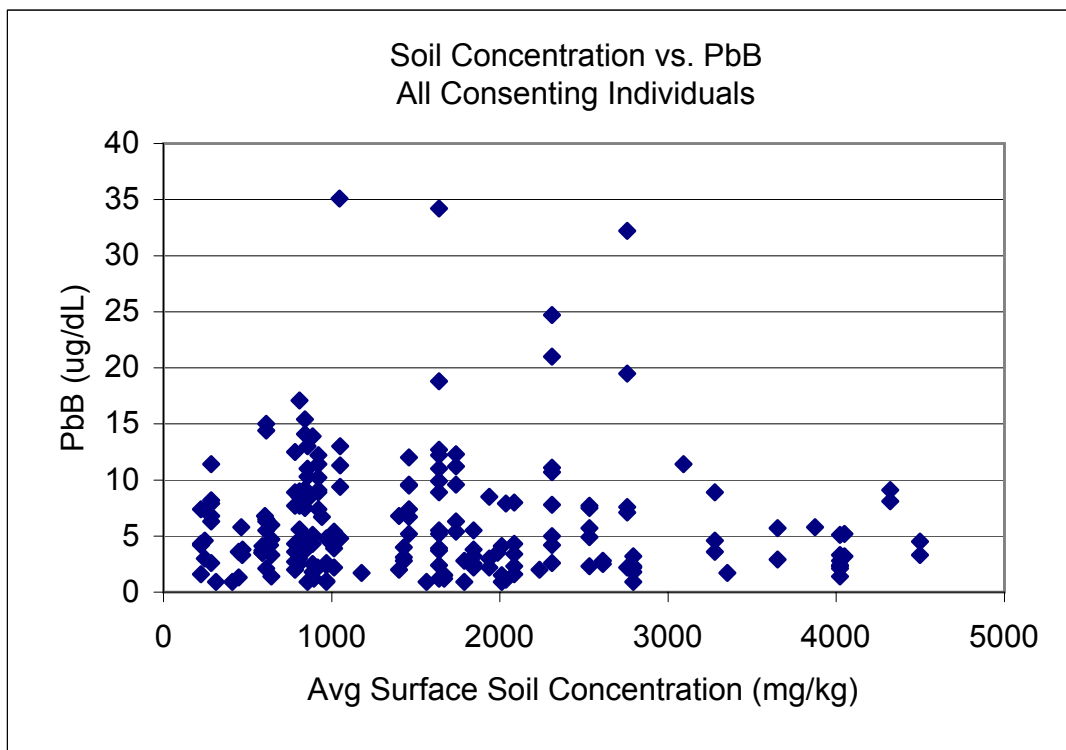
Figure 5-5: Blood Lead versus Soil Lead Concentrations in Exposure Areas

Blood Leads vs Area Soil Lead Concentrations in Children (0-72 months)

Blood Lead (ug/dL) vs Average Residential Exposure Area Concentration (mg/kg)

Blood Leads vs Area Soil Lead Concentrations in Children (0-72 months)

Blood Lead (ug/dL) vs Average Exposure Area (includes both Residential and Non-Residential sampels) Concentration (mg/kg)
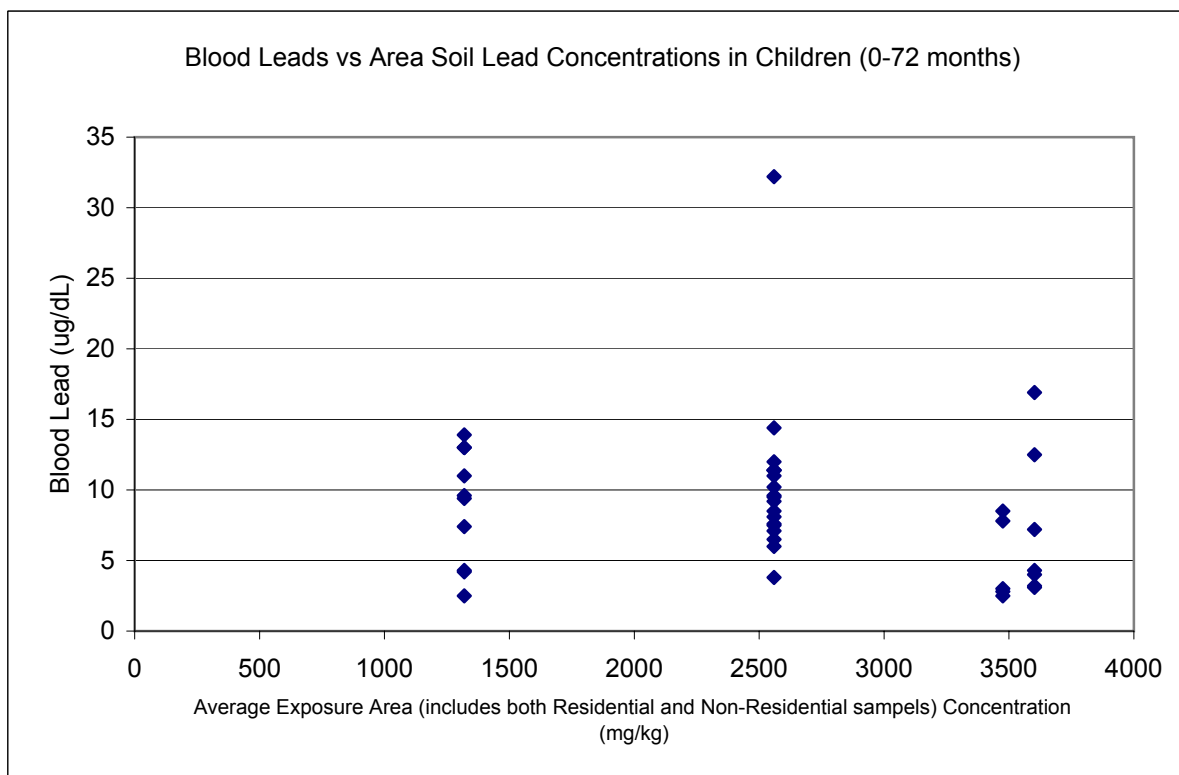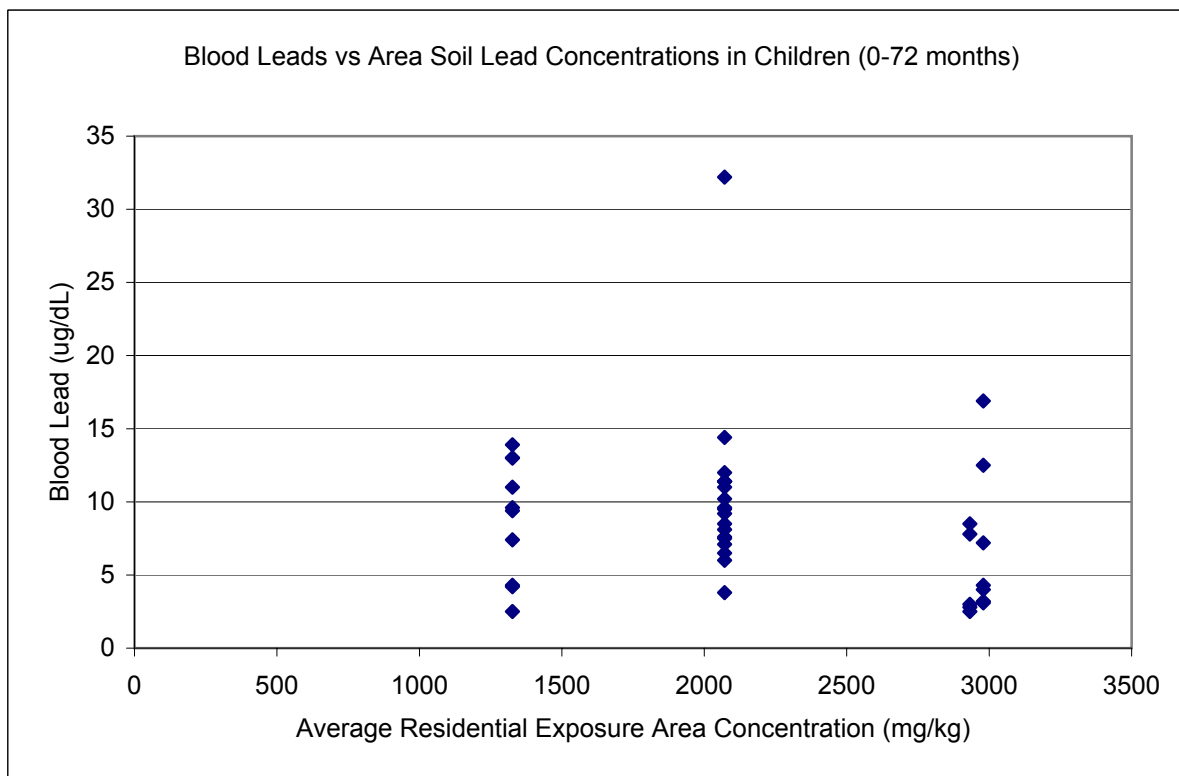
Figure 5-6: Blood Lead versus Dust Lead

Dust Concentration vs. PbB
All Consenting Individuals

Dust Loading* vs. PbB
All Consenting Individuals

Dust Concentration vs. PbB
Consenting Children (0-6)

Dust Loading* vs. PbB
Consenting Children (0-6)
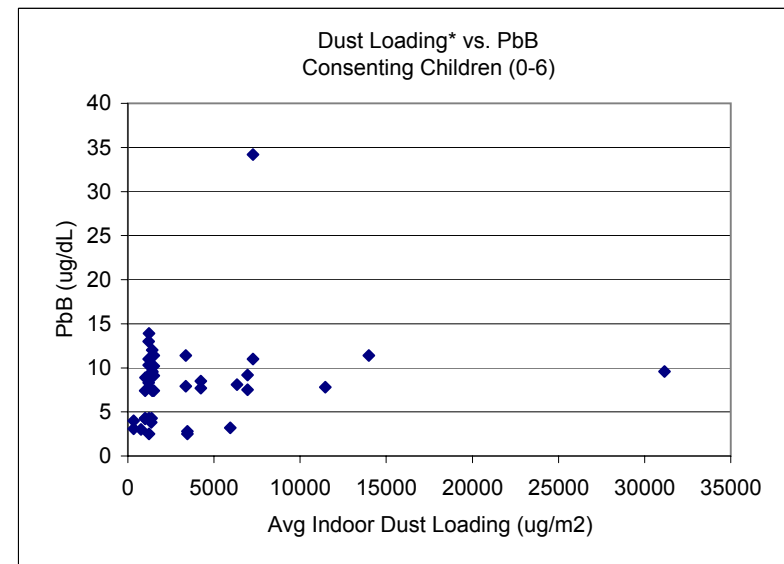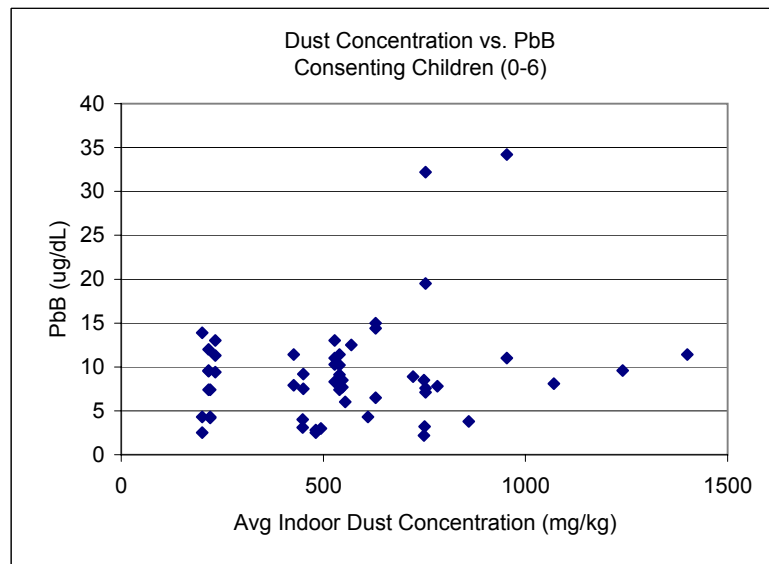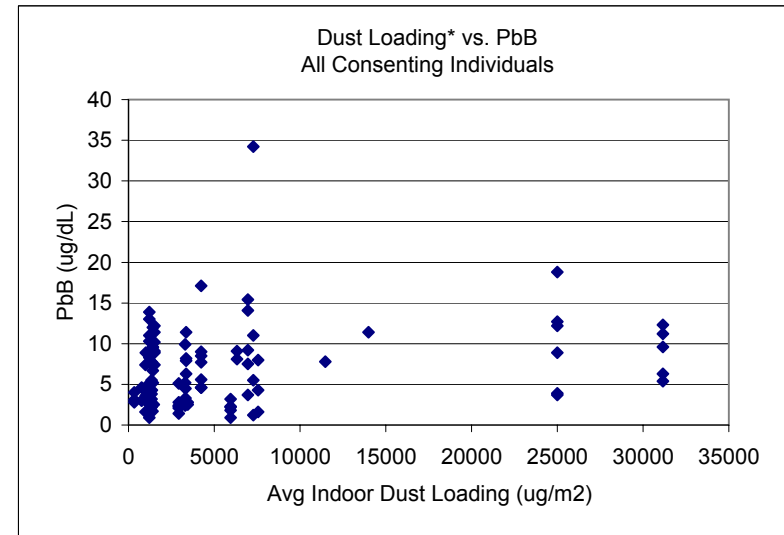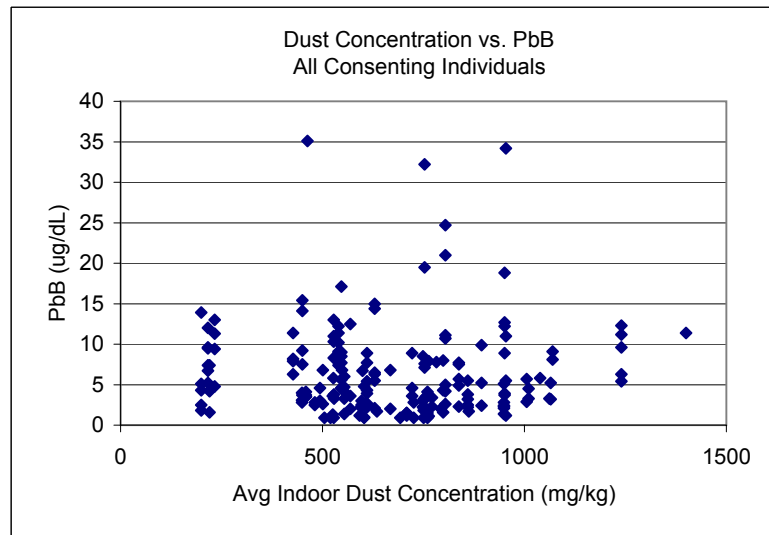
* Note: Loading values not available for all properties

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Figure 5-7: Blood Lead versus Surface Paint Lead Concentrations

Surface Paint Concentration vs PbB
All Consenting Individuals

Surface Paint Concentration vs PbB
Children 0-6

I:\Eureka\Final Data\Blood Lead\PbB vs Environmental.xls
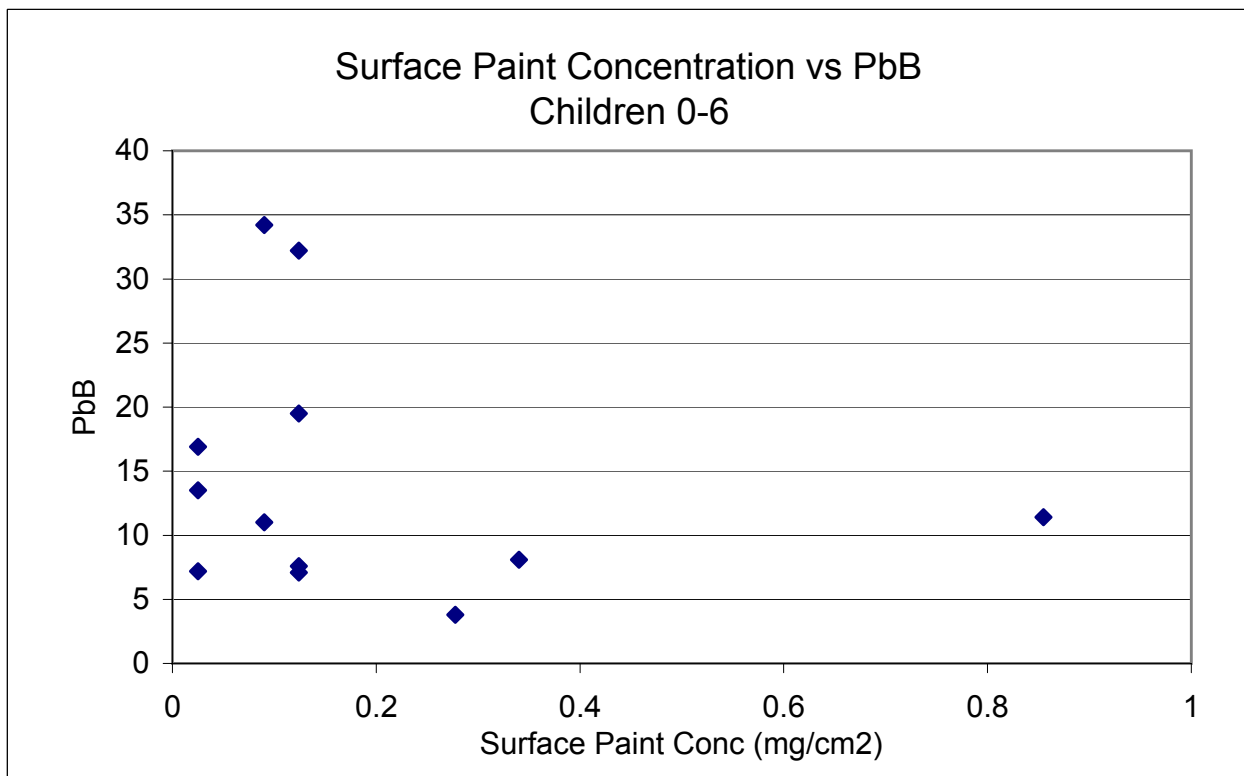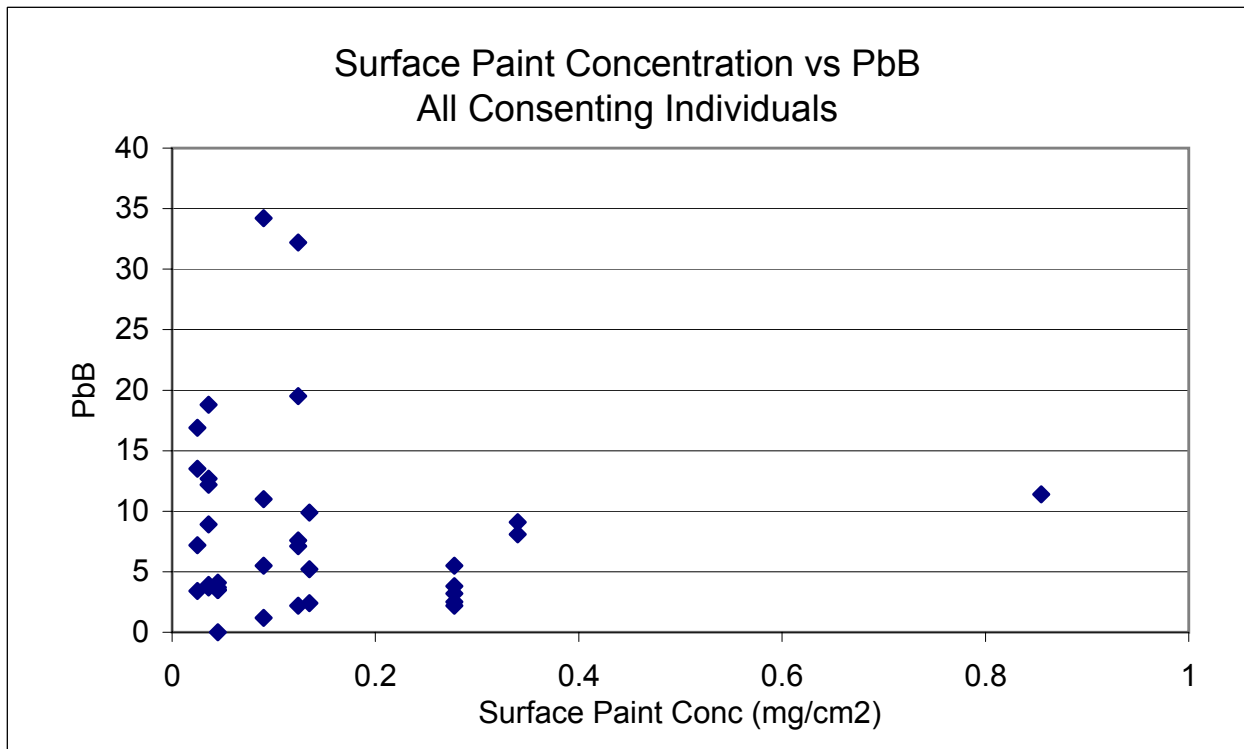
Figure 5-8: Total Blood Lead versus Surface Paint Lead Concentrations

Total Paint Concentration vs PbB
All Consenting Individuals

Total Paint Concentration vs PbB
Children (0-6)
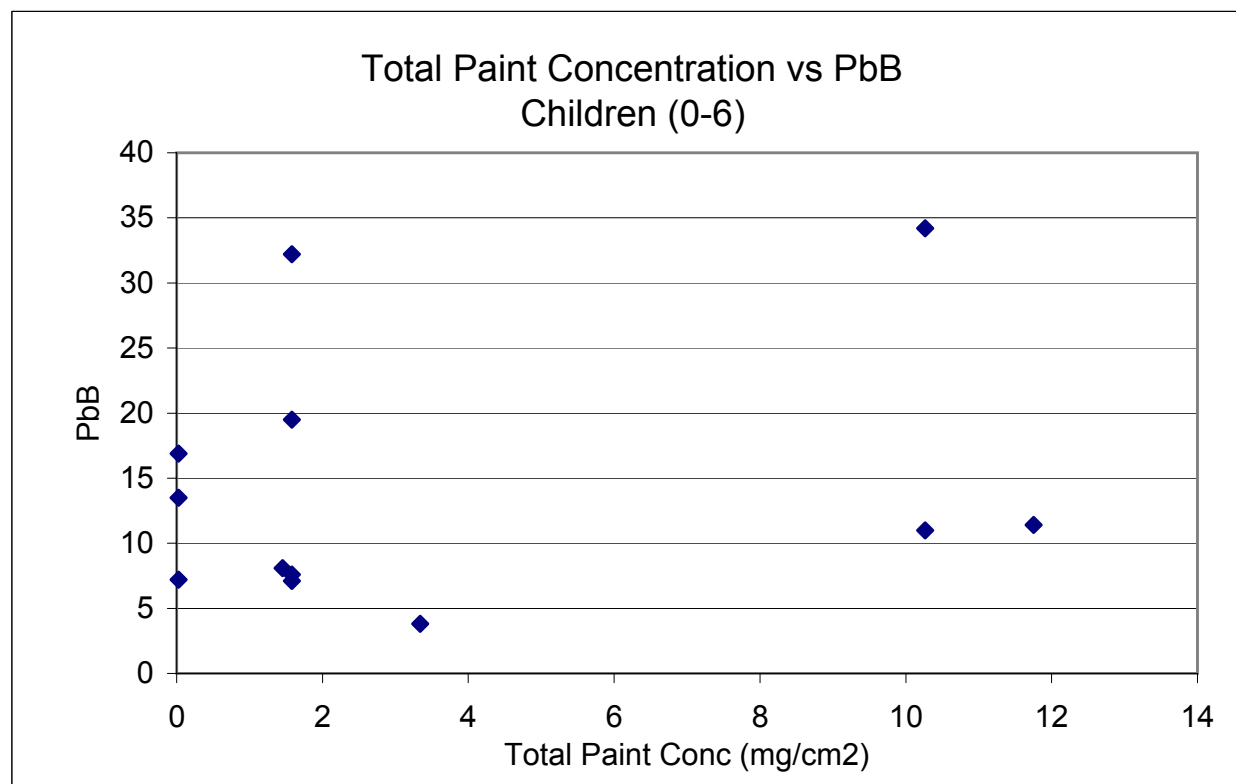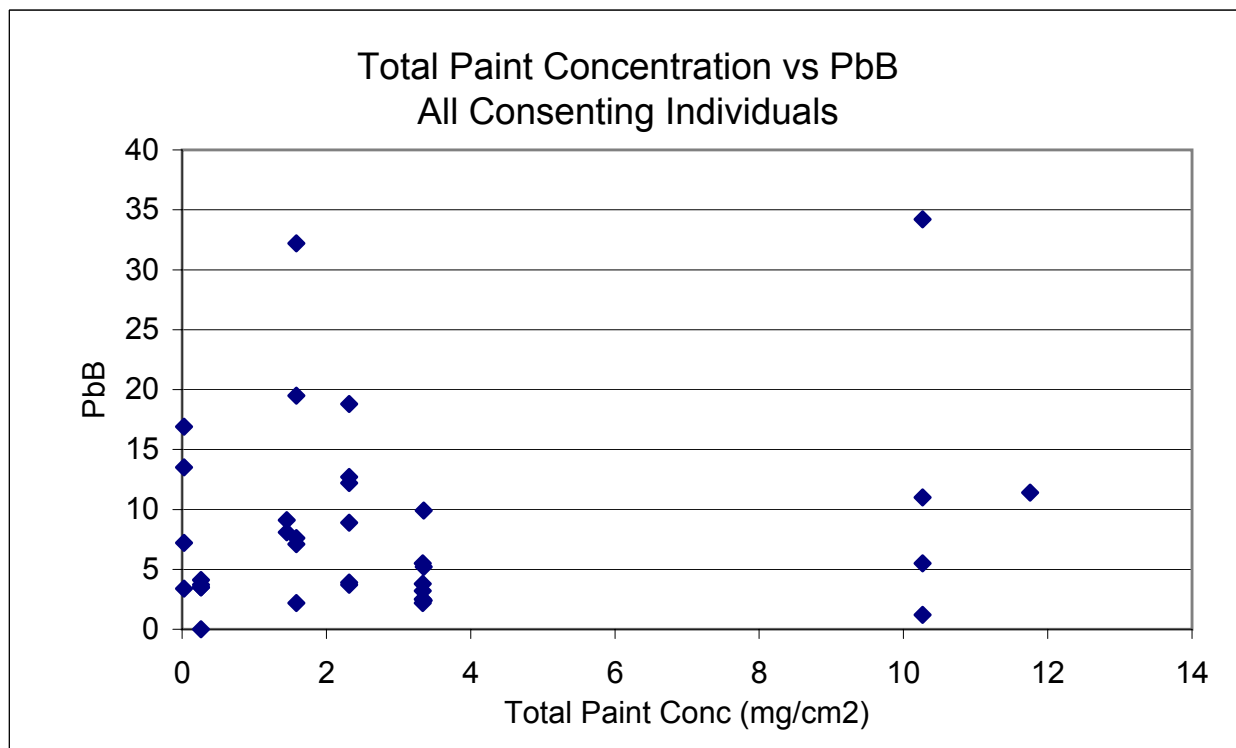
Figure 5-9: Eureka Blood Lead Stratified by Age

All Participants

PbB = 10

Blood Lead (ug/dL) vs Age (yrs)

All Children 0-6 years

PbB = 10

Blood Lead (ug/dL) vs Age (yrs)
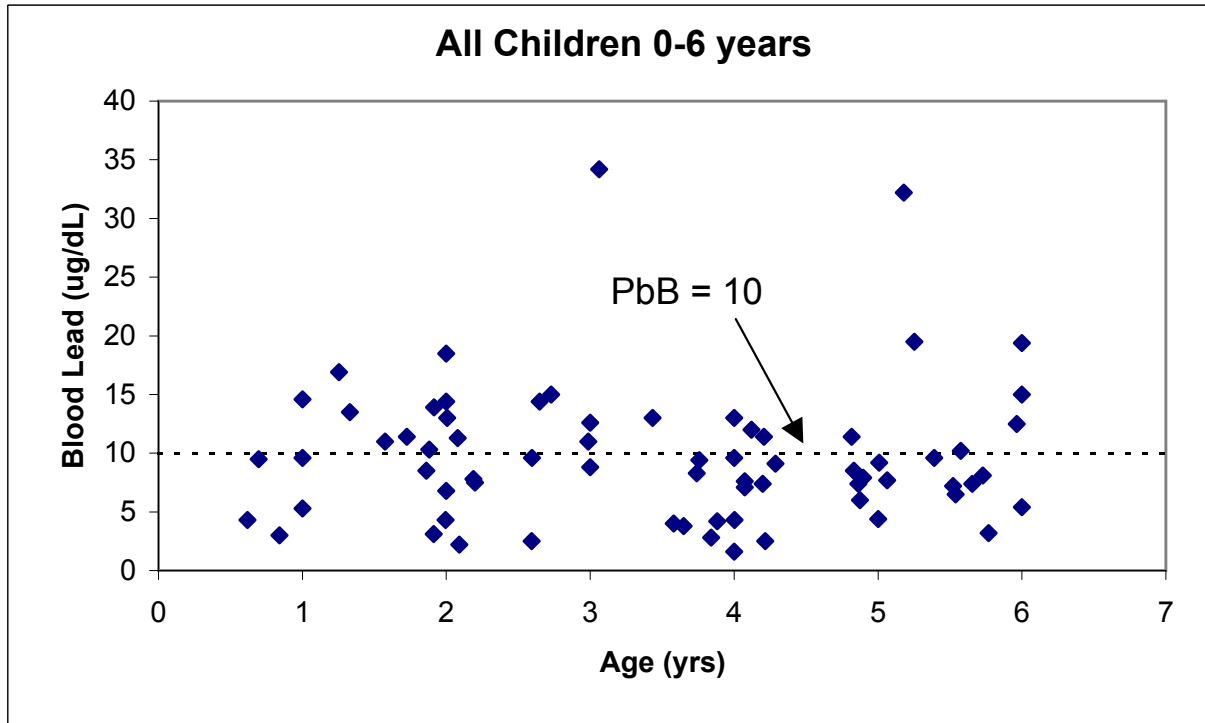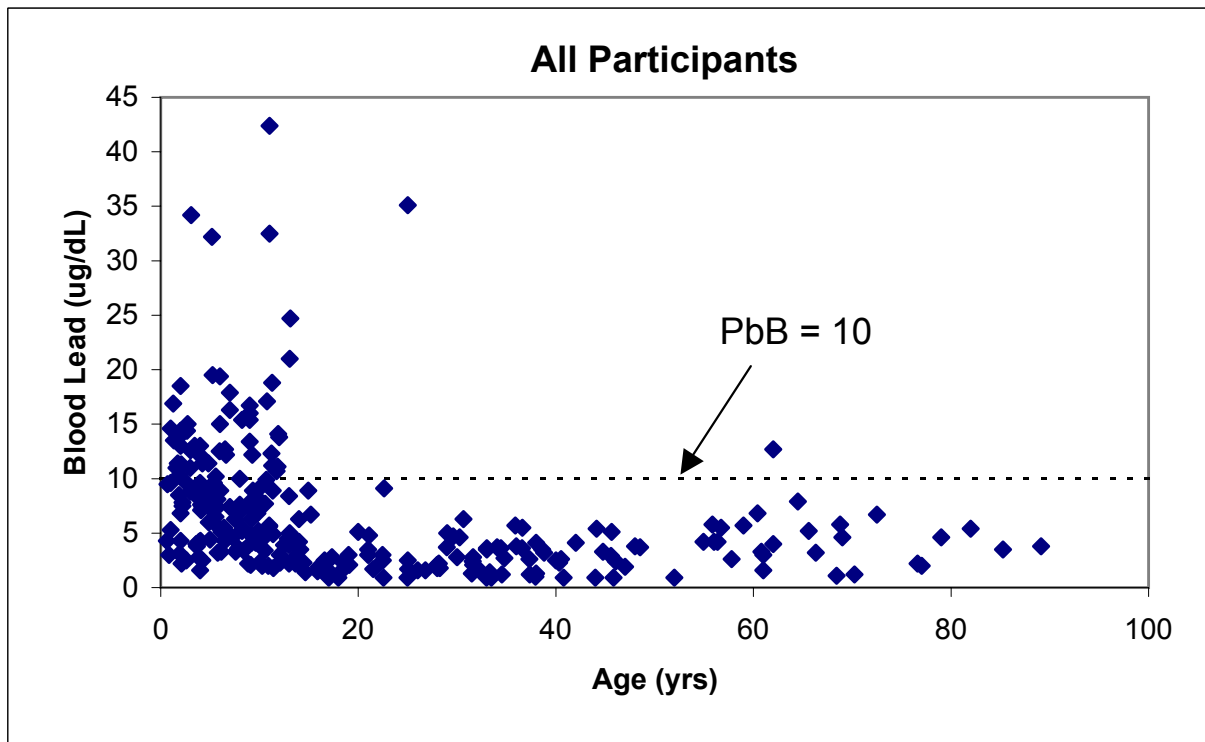
Figure 5-10: Observed vs Predicted Pb for Children (0-6 yrs)

$y = 0.1074x + 9.8287$
$R^2 = 0.0209$

Predicted PbB (ug/dL)

Observed PbB (ug/dL)

I:\Eureka\Risk Calcs\Residential\Batch Runs\PbB obs vs pred.xls
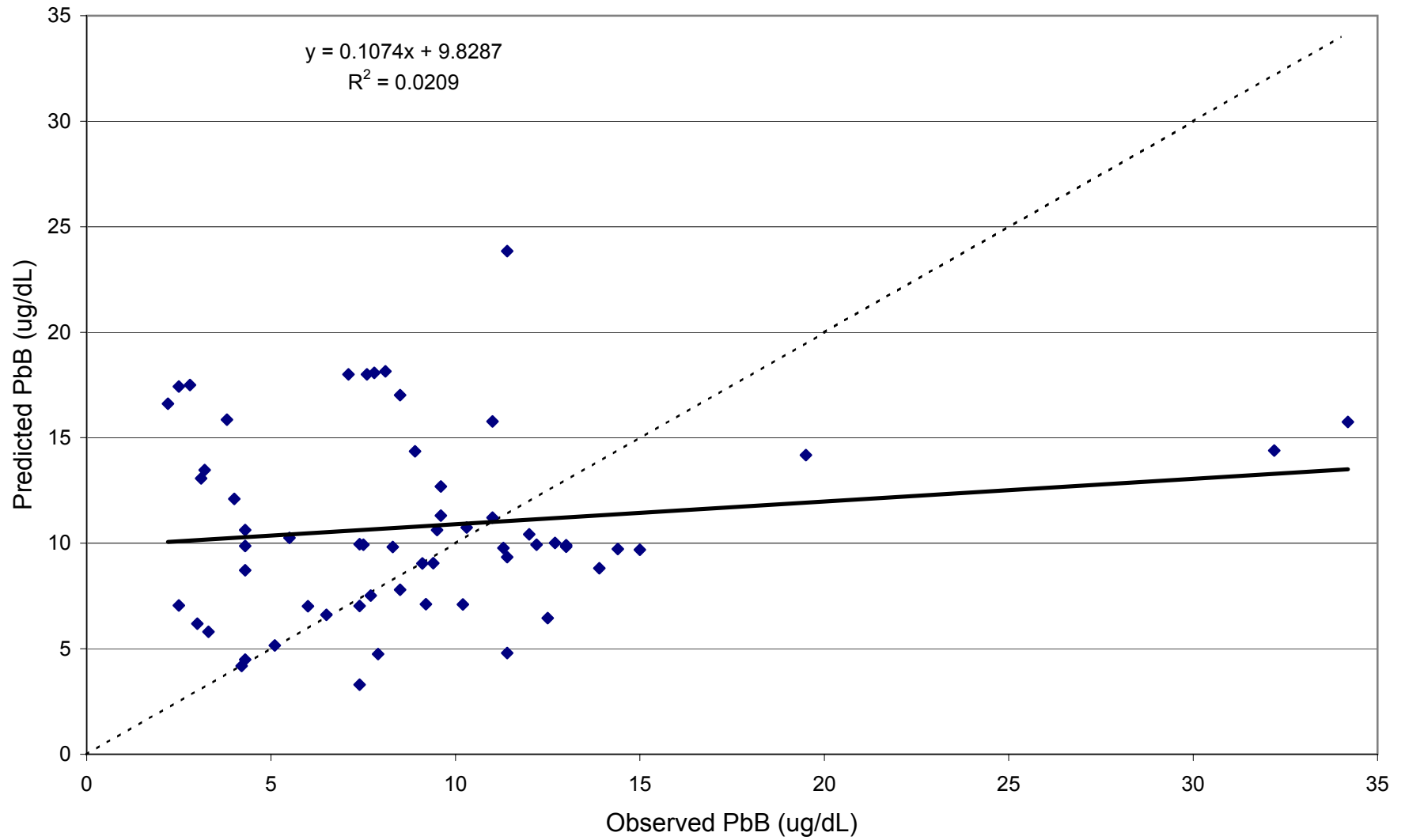
Figure 5-11: Lead Residuals

PbB Residual vs Soil Concentration

y = 0.0035x - 3.0646
R^2 = 0.2064

PbB Residual vs Dust Concentration

y = 0.005x - 1.0737
R^2 = 0.0403

I:\Eureka\Risk Calcs\Residential\Batch Runs\PbB obs vs pred.xls
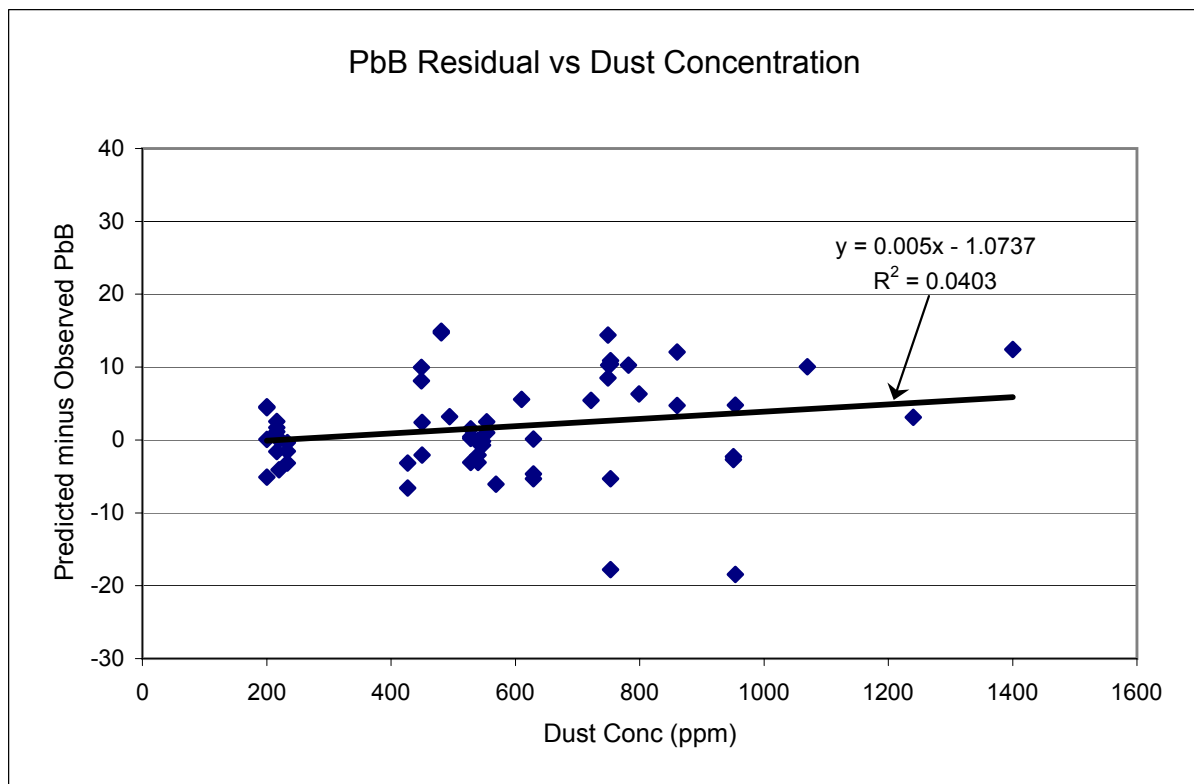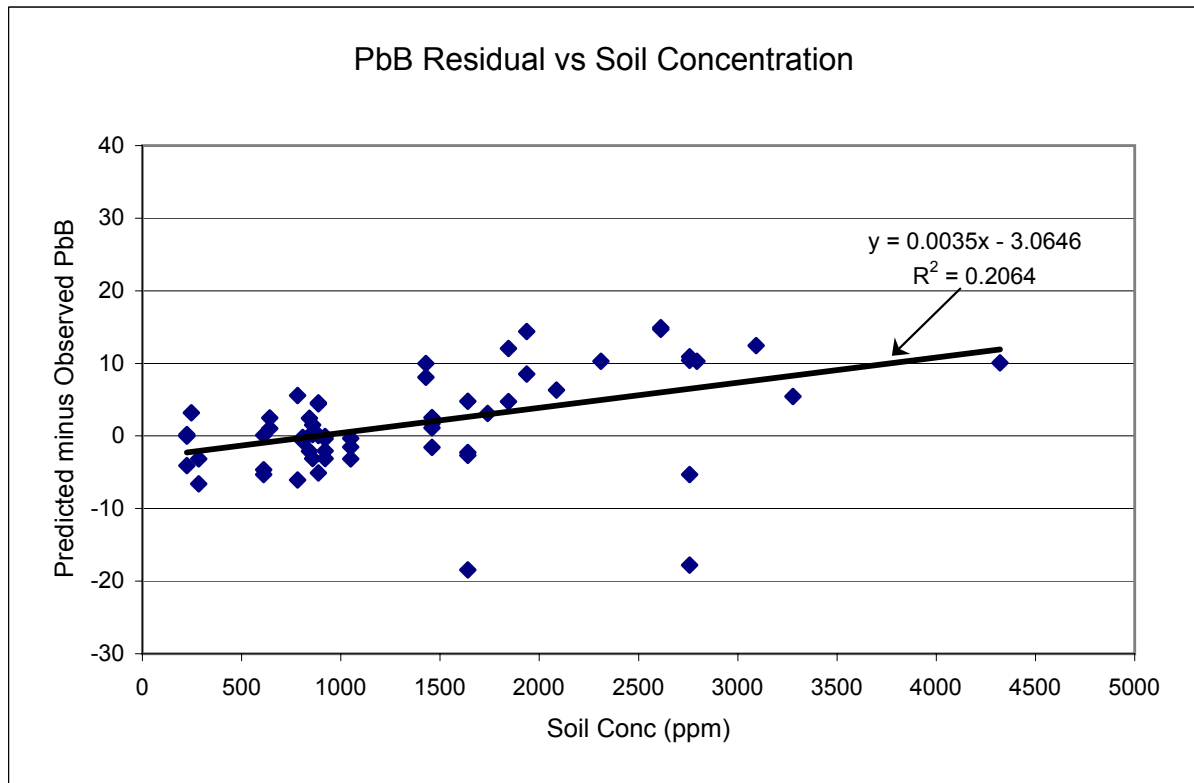
APPENDIX A

ANALYSIS OF XRF DATA QUALITY FOR SOILS FROM DATA SETS 1 AND 2

Appendix A
Analysis of XRF Data Quality for Soils from Data Sets 1 and 2

Data Set #1

A total of 4,211 residential soils were collected from varying depths at this site. All samples were analyzed for 13 metals by X-ray Fluorescence Spectroscopy (XRF), and approximately 10% (N=394) of these samples were also analyzed by Inductively Coupled Plasma Spectroscopy (ICP) for 23 metals. Results are shown in Table A-1 (XRF) and Table A-2 (ICP).

Inspection of Table A-1 shows that a number of analytes were never detected (chromium, nickel, selenium, silver), or were detected only infrequently (antimony, arsenic, cadmium, cobalt, copper, mercury) by XRF, even though these same analytes were usually detected by ICP (Table A-2). This raises concern that the detection limit (DL) obtained by XRF may have been too high to assess risk for some analytes. To investigate this, the DL by XRF was compared to levels needed for risk assessment purposes using the Region 3 Risk Based Concentration (RBC) Table for residential soils (USEPA, 1999). This comparison is presented in Table A-3 As seen, the DL was considered adequate for risk assessment purposes for only 5 out of the 13 chemicals analyzed via XRF.

The quality of the residential XRF data set (Data Set 1) was also evaluated by comparing detected concentrations to their corresponding (paired) ICP values. This was done by plotting XRF (y-axis) versus ICP (x-axis) and fitting a straight regression line through the data. Example graphs for 2 chemicals are shown in Figure A-1. Results for all chemicals are provided in Table A-4. In cases where the R^2 value was less than about 0.6, it was concluded that the accuracy of the XRF method for analysis of that chemical was unacceptably low compared to ICP. Based on this comparison, results for only 5 of 13 chemicals were judged to be reliable. For those chemicals whose results are deemed reliable, an adjustment to the XRF concentration based on the regression parameters can be made to account for any over- or under-estimation of true concentrations.

Table A-5 combines the results of these two data quality reviews and provides a conclusion of the overall data adequacy. In order for an XRF data set to be judged reliable for use in the risk assessment, both DL and correlation with ICP had to be listed as adequate. As shown, results for 4 chemicals (copper, iron, lead, zinc) met both of these criteria.

Table A-1: Summary Statistics for Data Set #1 Analyzed via XRF

Analyte	Detection Frequency (%)	Non Detects (mg/kg)			Detects Only (mg/kg)		
		Avg	Min	Max	Avg	Min	Max
antimony	1415/4211 (34%)	43	15	260	257	34	790
arsenic	57/4211 (1%)	89	15	2,500	361	15	2,800
barium	4205/4211 (99.8%)	112	100	140	830	85	8,300
cadmium	323/4211 (8%)	43	8	110	73	29	250
chromium	0/4211 (0%)	--	--	--	ND	ND	ND
cobalt	170/4211 (4%)	447	81	1,500	601	250	1,800
copper	695/4211 (16%)	58	13	160	294	57	2700
iron	4208/4211 (99.9%)	--	--	--	19,649	5,600	88,000
lead	3674/4211 (87%)	68	18	190	1,410	21	25,000
manganese	3223/4211 (77%)	2,340	180	4,900	1,413	360	8,500
mercury	158/4211 (4%)	33	10	120	48	14	290
nickel	0/4211 (0%)	94	15	260	ND	ND	ND
selenium	0/4211 (0%)	--	--	--	ND	ND	ND
silver	0/4211 (0%)	--	--	--	ND	ND	ND
zinc	4068/4211 (97%)	58	26	96	1,509	34	44,000

ND - analyte was not detected

– no numeric values were provided, values were listed as ND in the data tables

Table A-2 Summary Statistics for Data Set #1 Analyzed by ICP

Analyte	Detection Frequency (%)	Avg* (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	394/394 (100%)	11,826	1,100	20,000
Antimony	27/30 (90%)	19	10	59
Arsenic	394/394 (100%)	141	7.7	2,100
Barium	394/394 (100%)	326	91	1,200
Berylium	394/394 (100%)	0.92	0.19	1.8
Cadmium	394/394 (100%)	19	0.5	140
Calcium	394/394 (100%)	49,968	5,200	250,000
Chromium	394/394 (100%)	17	2	110
Cobalt	394/394 (100%)	5.7	1.1	15
Copper	394/394 (100%)	169	12	2,900
Iron	394/394 (100%)	18,576	9,000	83,000
Lead	394/394 (100%)	2,987	110	37,000
Magnesium	394/394 (100%)	18,741	2,100	84,000
Manganese	394/394 (100%)	1,054	220	5,100
Mercury	394/394 (100%)	3.3	0.04	130
Nickel	394/394 (100%)	12	3.4	34
Potassium	394/394 (100%)	3,346	390	6,200
Selenium	115/370 (31%)	0.79	0.5	8.3
Silver	351/384 (91%)	11	1	190
Sodium	394/394 (100%)	333	59	3,700
Thallium	53/391 (14%)	56	31	200
Vanadium	394/394 (100%)	26	7.7	330
Zinc	394/394 (100%)	2,687	120	26,000

Table A-3 Comparison of Detection Limits by XRF in Data Set #1 to RBCs

Analyte	Detection Frequency (%) - XRF	DL Range - XRF (mg/kg)	RBC* (mg/kg)	DL Adequate?[+]
antimony	1415/4211 (34%)	15 - 260	3.1	NO
arsenic	57/4211 (1%)	15 - 2,500	0.043	NO
barium	4205/4211 (99.8%)	100 - 140	550	YES
cadmium	323/4211 (8%)	8 - 110	7.8	NO
chromium	0/4211 (0%)	----	23	Unknown
cobalt	170/4211 (4%)	81 - 1500	470	Marginal
copper	695/4211 (16%)	13 - 160	310	YES
iron	4208/4211 (99.9%)	----	2,300	YES
lead	3674/4211 (87%)	18 - 190	400 **	YES
manganese	3223/4211 (77%)	180 - 4,900	160	NO
mercury	158/4211 (4%)	10 - 120	2.2***	NO
nickel	0/4211 (0%)	15 - 260	160	Marginal
selenium	0/4211 (0%)	----	39	Unknown
silver	0/4211 (0%)	----	39	Unknown
zinc	4068/4211 (97%)	26 - 96	2,300	YES

* Based on Region 3 Risk Based Concentrations at an HQ = 0.1 or Risk = 1E-05

** US EPA guidance for residential lead samples (USEPA, 2001)

*** Based on Region 9 Risk Based Concentration at an HQ = 0.1

[+] DL is Adequate if detection frequency is high (e.g., >80%), or if the DF is <80% and DL range is below the RBC

Figure A-1 Sample Regressions for XRF vs ICP analyses in Residential Soils

Barium

$y = 1.7053x + 264.62$
$R^2 = 0.2715$

XRF (mg/kg) vs ICP (mg/kg)

Copper

$y = 1.1486x + 56.15$
$R^2 = 0.8398$

XRF (mg/kg) vs ICP (mg/kg)
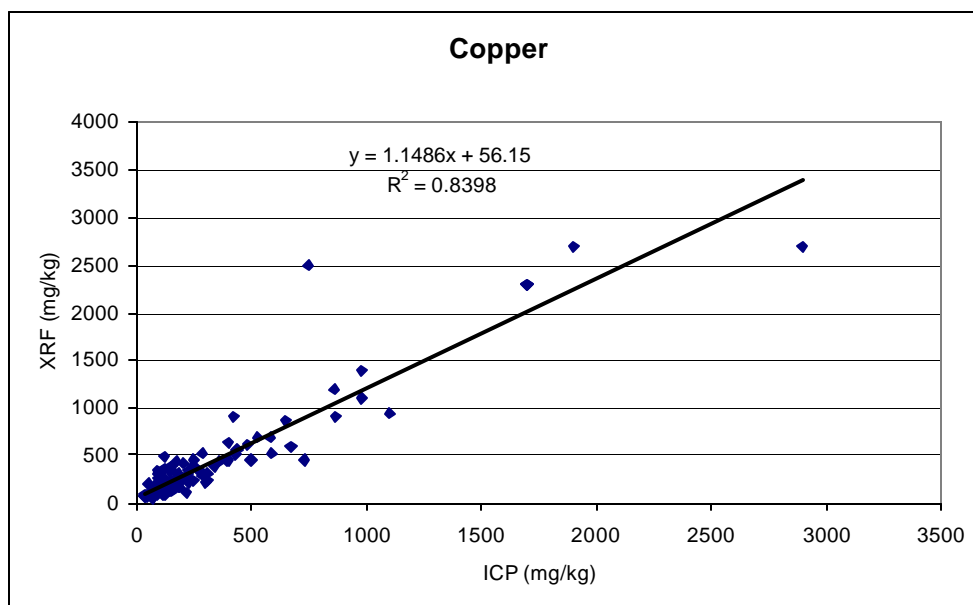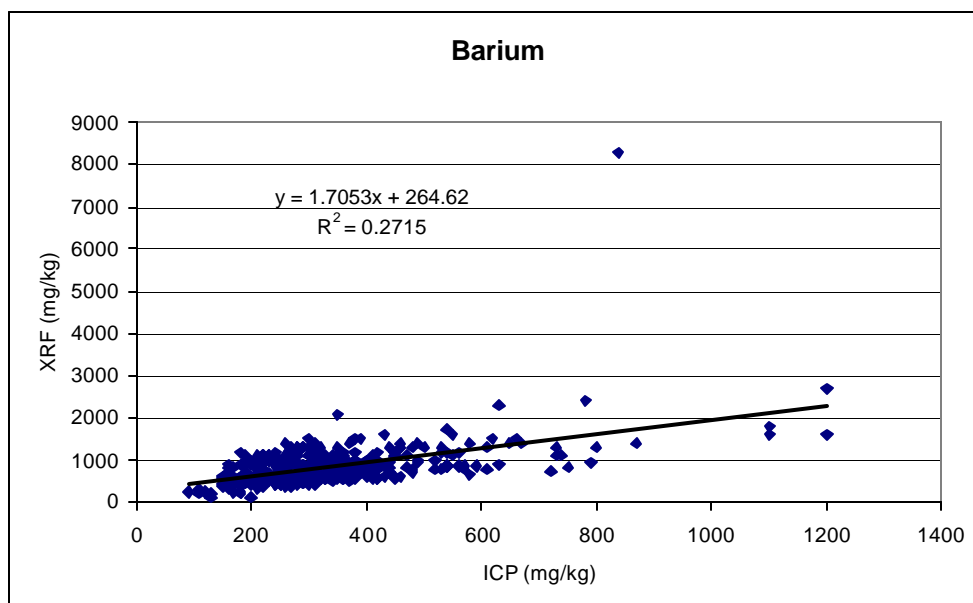
Table A-4 Correlation of XRF to ICP - Data Set #1

Analyte	N (paired data)	Intercept	Slope	Correlation (R²)	Correlation Adequate?*
antimony	15	1.8	12.7	0.444	NO
arsenic	5	-193	1.36	0.963	YES
barium	396	260	1.71	0.274	NO
cadmium	50	57	0.31	0.115	NO
chromium	--	--	--	--	Unknown
cobalt	23	1,167	-78.6	0.064	NO
copper	110	54.6	1.15	0.840	YES
iron	396	-651	1.17	0.767	YES
lead	397	312	0.66	0.924	YES
manganese	313	533	1.12	0.548	Marginal
mercury	29	53	2.42	0.136	NO
nickel	--	--	--	--	Unknown
selenium	--	--	--	--	Unknown
silver	--	--	--	--	Unknown
zinc	397	-207	1.09	0.954	YES

Non-Detects not Evaluated in Correlation

– Could not be evaluated due to no detected values in XRF data set

ICP = X-axis; XRF = y-axis

* $R^2 > 0.6$

linear regression equation: XRF[ ]=intercept + slope * ICP[ ]

Table A-5   Data Quality Summary - Data Set #1

Analyte	DL Adequate?	Correlation Adequate?	Data Set Reliable?
antimony	NO	NO	NO
arsenic	NO	YES	NO
barium	YES	NO	NO
cadmium	NO	NO	NO
chromium	Unknown	Unknown	NO
cobalt	Marginal	NO	NO
copper	YES	YES	**YES**
iron	YES	YES	**YES**
lead	YES	YES	**YES**
manganese	NO	Marginal	NO
mercury	NO	NO	NO
nickel	Marginal	Unknown	NO
selenium	NO	Unknown	NO
silver	NO	Unknown	NO
zinc	YES	YES	**YES**

*Non Detects Evaluated at the Detection Limit

Data Set #2

A total of 265 non-residential soils were collected from varying depths at this site. All samples were analyzed for 26 metals by XRF, and approximately 13% (N= 36) of these samples were also analyzed by ICP for 23 metals. Results are shown in Table A-6 (XRF) and Table A-7 (ICP).

Inspection of Table A-6 shows that several analytes were detected infrequently by XRF, even though these same analytes were detected frequently by ICP (Table A-7). This suggests that the detection limit obtained by XRF may have been too high for some analytes. To investigate this, the DL by XRF for each chemical was compared to the level needed for risk assessment purposes. This comparison is presented in Table A-8. As seen, the DL was considered adequate for calcium, chromium - LO, copper, iron, lead, molybdenum, potassium, rubidium, selenium, strontium, tin, titanium, uranium, zinc, zirconium.

The quality of Data Set 2 was also evaluated by comparing detected concentrations to their corresponding (paired) ICP values. This was done by plotting XRF (y-axis) versus ICP (x-axis) and fitting a straight regression line through the data. Results for all chemicals are provided in Table A-9 In cases where the R^2 value was less than about 0.6, it was concluded that the accuracy of the XRF method for analysis of that chemical was unacceptably low compared to ICP. Several chemicals could not be examined in this manner because they were only evaluated with one analytical method. The following chemicals were analyzed by XRF only: molybdenum, rubidium, strontium, thorium, tin, titanium, uranium, and zirconium. Aluminum, magnesium, sodium, thallium, and vanadium were only analyzed via ICP. Based on the comparison of the remaining chemicals, results for antimony, barium, calcium, copper, lead, manganese, potassium, and zinc were judged to be reliable. For these chemicals, an adjustment to the XRF concentration based on the regression parameters can be made to account for any over- or under-estimation of true concentrations, if necessary.

Table A-10 combines the results of the data quality reviews and provides a conclusion of the overall data adequacy. In order for a XRF data set to be judged reliable for use in the risk assessment, both DL and correlation with ICP had to be listed as adequate. As shown, results for calcium, copper, lead, potassium, and zinc met these standards.

Table A-6: Summary Statistics for Data Set #2 Analyzed via XRF
Soils from Non-Residential Areas

Analyte	Detection Frequency (%)	Non Detects (mg/kg)			Detects Only (mg/kg)		
		Avg	Min	Max	Avg	Min	Max
antimony	110/265 (42%)	54	42	72	126	45	690
arsenic	9/265 (3.4%)	442	51	5,100	276	65	480
barium	265/265 (100%)	--	--	--	639	60	3,600
cadmium	30/265 (11%)	169	72	240	217	72	560
calcium	265/265 (100%)	--	--	--	58,458	8,500	250,000
chromium- HI	41/265 (15%)	584	490	510	726	510	1,300
chromium- LO	0/265 (0%)	11	10	17	--	--	--
cobalt	33/265 (12%)	542	250	730	418	250	770
copper	144/266 (54%)	80	74	88	457	80	2,200
iron	265/265 (100%)	--	--	--	22,164	8,700	53,000
lead	258/265 (97%)	46	37	50	4,334	36	51,000
manganese	201/265 (76%)	688	590	770	1,883	620	8,900
mercury	68/265 (26%)	60	51	72	146	51	770
molybdenum	0/265 (0%)	11	10	17	--	--	--
nickel	5/265 (1.9%)	114	77	180	132	79	230
potassium	264/265 (99.6%)	3,200	3,200	3,200	16,747	2,600	35,000
rubidium	260/265 (98%)	34	30	37	87	25	140
selenium	5/265 (1.9%)	31	24	39	35	25	56
silver	43/265 (16%)	113	94	140	166	95	290
strontium	265/265 (100%)	--	--	--	242	43	490
thorium	45/265 (17%)	19	14	22	30	14	63
tin	3/265 (1.1%)	108	85	130	143	110	200
titanium	226/265 (85%)	896	750	940	1,882	800	4,700
uranium	13/265 (4.9%)	20	11	30	16	11	25
zinc	265/265 (100%)	--	--	--	4,295	58	26,000
zirconium	265/265 (100%)	--	--	--	204	23	400

Soils from Background Areas

Analyte	Detection Frequency (%)	Non Detects (mg/kg)			Detects Only (mg/kg)		
		Avg	Min	Max	Avg	Min	Max
antimony	0/18 (0%)	70	65	72	--	--	--
arsenic	2/18 (11%)	53	47	93	64	64	64
barium	18/18 (100%)	--	--	--	586	160	1800
cadmium	0/18 (0%)	223	180	240	--	--	--
calcium	18/18 (100%)	--	--	--	40833	12000	132000
chromium- HI	1/18 (6%)	612	490	650	610	610	610
chromium- LO	0/18 (0%)	502	480	510	--	--	--
cobalt	0/18 (0%)	564	500	730	--	--	--
copper	0/18 (0%)	76	74	77	--	--	--
iron	18/18 (100%)	--	--	--	21333	16000	27000
lead	17/18 (94%)	32	32	32	169	40	930
manganese	9/18 (50%)	606	590	610	931	640	1400
mercury	0/18 (0%)	66	51	72	--	--	--
molybdenum	0/18 (0%)	16	12	17	--	--	--
nickel	0/18 (0%)	163	120	180	--	--	--
potassium	18/18 (100%)	--	--	--	20000	15000	24000
rubidium	18/18 (100%)	--	--	--	96	66	120
selenium	0/18 (0%)	25	24	27	--	--	--
silver	0/18 (0%)	129	94	140	--	--	--
strontium	18/18 (100%)	--	--	--	282	160	480
thorium	0/18 (0%)	17	15	21	--	--	--
tin	0/18 (0%)	118	85	130	--	--	--
titanium	18/18 (100%)	--	--	--	2422	1700	3000
uranium	5/18 (28%)	13	11	13	16	13	20
zinc	16/18 (89%)	91	91	91	214	91	790
zirconium	18/18 (100%)	--	--	--	268	170	430

Table A-7 Summary Statistics for Data Set #2 Analyzed via ICP

Analyte	Non-Residential Detection Frequency (%)	Avg (mg/kg)	Min (mg/kg)	Max (mg/kg)	Background Detection Frequency (%)	Avg (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	36/36 (100%)	4,807	88	12,800	3/3 (100%)	9,583	7,240	11,700
Antimony	30/36 (83%)	43	0.5	330	0/3 (0%)	0.7	0.5	1.1
Arsenic	35/36 (97%)	414	0.4	1,100	3/3 (100%)	9.5	4.2	13.4
Barium	35/36 (97%)	324	0.33	1,100	3/3 (100%)	228	118	285
Beryllium	36/36 (100%)	0.56	0.1	1.4	3/3 (100%)	0.66	0.61	0.7
Cadmium	35/36 (97%)	60	0.2	171	3/3 (100%)	0.38	0.21	0.56
Calcium	35/36 (97%)	62,252	39	186,000	3/3 (100%)	42,097	3,790	54,400
Chromium	35/36 (97%)	14	0.3	220	3/3 (100%)	7.9	2.5	12.3
Cobalt	35/36 (97%)	5.65	0.2	17	3/3 (100%)	5.7	4.5	7.3
Copper	35/36 (97%)	448	0.3	2,330	3/3 (100%)	11.3	4.3	15.1
Iron	36/36 (100%)	21,774	61	48,500	3/3 (100%)	12,800	11,100	14,000
Lead	36/36 (100%)	16,366	2.4	82,700	3/3 (100%)	34.3	17.9	55.9
Magnesium	35/36 (97%)	22,950	23	79,000	3/3 (100%)	14,390	3,230	34,700
Manganese	36/36 (100%)	1,759	1	5,750	3/3 (100%)	441	117	710
Mercury	34/36 (94%)	10.2	0.05	144	2/3 (67%)	0.06	0.05	0.066
Nickel	34/36 (94%)	18	0.3	111	3/3 (100%)	9.5	1.9	16.9
Potassium	35/36 (97%)	1,399	37	4,380	3/3 (100%)	2,623	2,350	2,940
Selenium	35/36 (97%)	3.86	0.4	18	3/3 (100%)	0.97	0.8	1.2
Silver	32/36 (89%)	49	0.2	165	1/3 (33%)	0.2	0.2	0.2
Sodium	33/36 (92%)	758	42	1,830	0/3 (0%)	41.6	41.6	41.6
Thallium	27/36 (75%)	16	0.6	68	1/3 (33%)	0.77	0.6	1.1
Vanadium	35/36 (97%)	26	0.3	238	3/3 (100%)	23.2	15.6	31.8
Zinc	35/36 (97%)	8,807	1.1	23,900	3/3 (100%)	58.6	36.3	79.8

Non Detects Evaluated at the Detection Limit

Table A-8: Comparison of Detection Limits by XRF in Data Set #2 to RBCs Soils from Mine Waste Areas

Analyte	Detection Frequency (%) - XRF	DL Range - XRF (mg/kg)	RBC* (mg/kg)	DL Adequate?[+]
antimony	110/265 (42%)	42 - 72	3.1	No
arsenic	9/265 (3.4%)	51 - 5100	0.043	No
barium	265/265 (100%)	--	550	Yes
cadmium	30/265 (11%)	72 - 240	7.8	No
calcium	265/265 (100%)	--		Yes
chromium- HI	41/265 (15%)	490 - 510	23	No
chromium- LO	0/265 (0%)	10 - 17	23	Yes
cobalt	33/265 (12%)	250 - 730	470	Marginal
copper	144/266 (54%)	74 - 88	310	Yes
iron	265/265 (100%)	--	2300	Yes
lead	258/265 (97%)	37 - 50	400	Yes
manganese	201/265 (76%)	590 - 770	160	No
mercury	68/265 (26%)	51 - 72	2.2	No
molybdenum	0/265 (0%)	10 - 17	39	Yes
nickel	5/265 (1.9%)	77 - 180	160	Marginal
potassium	264/265 (99.6%)	3200 - 3200		Yes
rubidium	260/265 (98%)	30 - 37		Yes
selenium	5/265 (1.9%)	24 - 39	39	Yes
silver	43/265 (16%)	94 - 140	39	No
strontium	265/265 (100%)	--	4700	Yes
thorium	45/265 (17%)	14 - 22		Unknown
tin	3/265 (1.1%)	85 - 130	4700	Yes
titanium	226/265 (85%)	750 - 940	31000	Yes
uranium	13/265 (4.9%)	11 - 30	23	Yes
zinc	265/265 (100%)	--	2300	Yes
zirconium	265/265 (100%)	--		Yes

* Based on Region 3 Risk Based Concentrations at an HQ = 0.1 or Risk = 1E-05 (USEPA, 1999)

** US EPA guidance for residential lead samples (USEPA, 2001)

[+] DL is Adequate if detection frequency is high (e.g., >80%), or if the DF is <80% and DL range is below the RBC

Soils from Background Areas

Analyte	Detection Frequency (%) - XRF	DL Range - XRF (mg/kg)	RBC* (mg/kg)	DL Adequate?[+]
antimony	0/18 (0%)	65 - 72	3.1	No
arsenic	2/18 (11%)	47 - 93	0.043	No
barium	18/18 (100%)	--	550	Yes
cadmium	0/18 (0%)	180 - 240	7.8	No
calcium	18/18 (100%)	--		Yes
chromium- HI	1/18 (6%)	490 - 650	23	No
chromium- LO	0/18 (0%)	480 - 510	23	No
cobalt	0/18 (0%)	500 - 730	470	No
copper	0/18 (0%)	74 - 77	310	Yes
iron	18/18 (100%)	--	2300	Yes
lead	17/18 (94%)	32 - 32	400	Yes
manganese	9/18 (50%)	590 - 610	160	No
mercury	0/18 (0%)	51 - 72	2.2	No
molybdenum	0/18 (0%)	12 - 17	39	Yes
nickel	0/18 (0%)	120 - 180	160	Marginal
potassium	18/18 (100%)	--		Yes
rubidium	18/18 (100%)	--		Yes
selenium	0/18 (0%)	24 - 27	39	Yes
silver	0/18 (0%)	94 - 140	39	No
strontium	18/18 (100%)	--	4700	Yes
thorium	0/18 (0%)	15 - 21		Unknown
tin	0/18 (0%)	85 - 130	4700	Yes
titanium	18/18 (100%)	--	31000	Yes
uranium	5/18 (28%)	11 - 13	23	Yes
zinc	16/18 (89%)	91 - 91	2300	Yes
zirconium	18/18 (100%)	--		Yes

* Based on Region 3 Risk Based Concentrations at an HQ = 0.1 or Risk = 1E-05

** US EPA guidance for residential lead samples (USEPA, 2001)

[+] DL is Adequate if detection frequency is high (e.g., >80%), or if the DF is <80% and DL range is below the RBC

Table A-9: Correlation of XRF to ICP - Data Set #2
Soils from Non-Residential Areas

Analyte	N (paired data)	Intercept	Slope	Correlation	Correlation Adequate?
antimony	21	57.6	1.88	0.854	Yes
arsenic	1	--	--	--	Insufficient
barium	32	-153	2.92	0.717	Yes
cadmium	7	114	1.67	0.216	No
calcium	32	11081	1.06	0.850	Yes
chromium-HI	8	1034	-40.88	0.148	No
chromium - LO	0	--	--	--	No Data
cobalt	5	514	3.75	0.005	No
copper	23	95.4	0.873	0.938	Yes
iron	32	11843	0.541	0.476	No
lead	32	451	0.599	0.927	Yes
manganese	29	381	1.23	0.685	Yes
mercury	20	191	0.466	0.032	No
molybdenum	0	--	--	--	No Data
nickel	4	86.8	1.24	0.380	No
potassium	32	6211	4.17	0.644	Yes
rubidium	0	--	--	--	No Data
selenium	3	--	--	--	Insufficient
silver	10	200	-0.152	0.018	No
strontium	0	--	--	--	No Data
thorium	0	--	--	--	No Data
tin	0	--	--	--	No Data
titanium	0	--	--	--	No Data
uranium	0	--	--	--	No Data
zinc	32	774	0.824	0.749	Yes
zirconium	0	--	--	--	No Data

Non-Detects not Evaluated in Correlation

– Could not be evaluated due to no detected values in XRF data set

ICP = X-axis; XRF = y-axis

linear regression equation: XRF[ ]=intercept + slope * ICP[ ]

Table A-10: Data Quality Summary - Data Set #2

Soils from Non-Residential Areas

Analyte	DL Adequate?	Correlation Adequate?	Data Set Reliable?
antimony	No	Yes	No
arsenic	No	Insufficient	No
barium	Yes	Yes	**Yes**
cadmium	No	No	No
calcium	Yes	Yes	**Yes**
chromium-HI	No	No	No
chromium - LO	Yes	No Data	No
cobalt	Marginal	No	No
copper	Yes	Yes	**Yes**
iron	Yes	No	No
lead	Yes	Yes	**Yes**
manganese	No	Yes	No
mercury	No	No	No
molybdenum	Yes	No Data	No
nickel	Marginal	No	No
potassium	Yes	Yes	**Yes**
rubidium	Yes	No Data	No
selenium	Yes	Insufficient	No
silver	No	No	No
strontium	Yes	No Data	No
thorium	Unknown	No Data	No
tin	Yes	No Data	No
titanium	Yes	No Data	No
uranium	Yes	No Data	No
zinc	Yes	Yes	**Yes**
zirconium	Yes	No Data	No

Soils from background areas were not evaluated for correlation to ICP data due to insufficient data.
Therefore, the reliability of these data will be based on the evaluations of non-residential area soils.

APPENDIX B
PHYSICAL-CHEMICAL DATA FOR EUREKA SOILS

SAMPLE ID EM-01

SUMMARY STATISTICS
EM-1 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract As	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Clays	1	1	85	85	85	0.5%	0.5%	2.39%	2.39%	3.1	0.00028	0.0%	0.0%	<5	49.0%	45.5%	5.0%	4.7%
Anglesite	2	2	61	3	118	1.0%	1.0%	3.40%	3.40%	6.3	0	0.0%	0.0%	5-9	23.0%	20.5%	10.1%	9.3%
Cerussite	36	36	17	1	105	18.0%	18.0%	17.64%	17.64%	6.6	0	0.0%	0.0%	10-19	6.5%	6.5%	11.0%	11.0%
Fe Oxide	50	50	26	2	125	25.0%	25.0%	36.12%	36.12%	4	0.011	31.7%	31.7%	20-49	9.0%	8.0%	34.0%	32.6%
Galena	1	0	1	1	1	0.5%	0.0%	0.03%	0.00%	7.5	0	0.0%	0.0%	50-99	8.0%	8.0%	20.6%	20.6%
Mn Oxide	29	23	35	2	155	14.5%	11.5%	28.12%	25.25%	5	0.0073	20.5%	18.4%	100-149	4.0%	4.0%	16.1%	16.1%
PbAsO	3	3	17	2	36	1.5%	1.5%	1.40%	1.40%	7.1	0.17	33.8%	33.8%	150-199	0.5%	0.5%	3.2%	3.2%
Phosphate	7	0	3	2	5	3.5%	0.0%	0.51%	0.00%	5	0.0093	0.5%	0.0%	200-249	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	47	47	7	1	90	23.5%	23.5%	9.04%	9.04%	3.7	0.02	13.3%	13.3%	≥250	0.0%	0.0%	0.0%	0.0%
ZnSiO4	24	24	2	2	2	12.0%	12.0%	1.35%	1.35%	3.9	0.0023	0.2%	0.2%					
															100%	93%	100%	97%
TOTAL	200	186	18			100.0%	93.0%	100.00%	96.60%			100.0%	97.4%					

SUMMARY STATISTICS
EM-1 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract Pb	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Clays	1	1	85	85	85	0.5%	0.5%	2.39%	2.39%	3.1	0.076	0.4%	0.4%	<5	49.0%	45.5%	5.0%	4.8%
Anglesite	2	2	61	3	118	1.0%	1.0%	3.40%	3.40%	6.3	0.684	10.0%	10.0%	5-9	23.0%	20.5%	4.1%	3.5%
Cerussite	36	36	17	1	105	18.0%	18.0%	17.64%	17.64%	6.6	0.776	61.6%	61.6%	10-19	6.5%	6.5%	5.3%	5.3%
Fe Oxide	50	50	26	2	125	25.0%	25.0%	36.12%	36.12%	4	0.047	4.6%	4.6%	20-49	9.0%	8.0%	17.4%	16.1%
Galena	1	0	1	1	1	0.5%	0.0%	0.03%	0.00%	7.5	0.866	0.1%	0.0%	50-99	8.0%	8.0%	37.8%	37.8%
Mn Oxide	29	23	35	2	155	14.5%	11.5%	28.12%	25.25%	5	0.193	18.5%	16.6%	100-149	4.0%	4.0%	27.6%	27.6%
PbAsO	3	3	17	2	36	1.5%	1.5%	1.40%	1.40%	7.1	0.633	4.3%	4.3%	150-199	0.5%	0.5%	2.9%	2.9%
Phosphate	7	0	3	2	5	3.5%	0.0%	0.51%	0.00%	5	0.037	0.1%	0.0%	200-249	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	47	47	7	1	90	23.5%	23.5%	9.04%	9.04%	3.7	0.0146	0.3%	0.3%	≥250	0.0%	0.0%	0.0%	0.0%
ZnSiO4	24	24	2	2	2	12.0%	12.0%	1.35%	1.35%	3.9	0.011	0.0%	0.0%					
															100%	93%	100%	98%

MINERAL FREQUENCY OBSERVED IN SITE SOIL
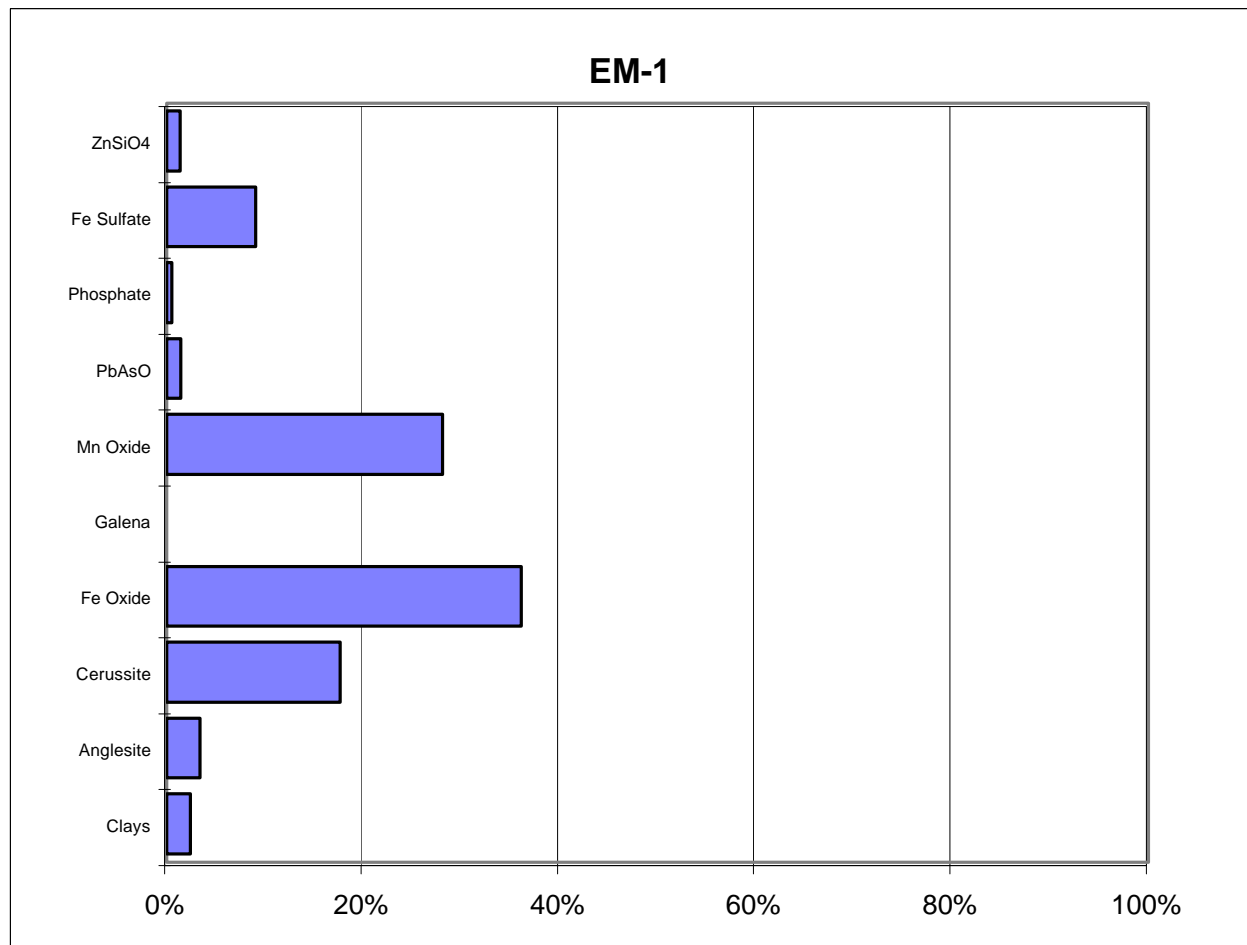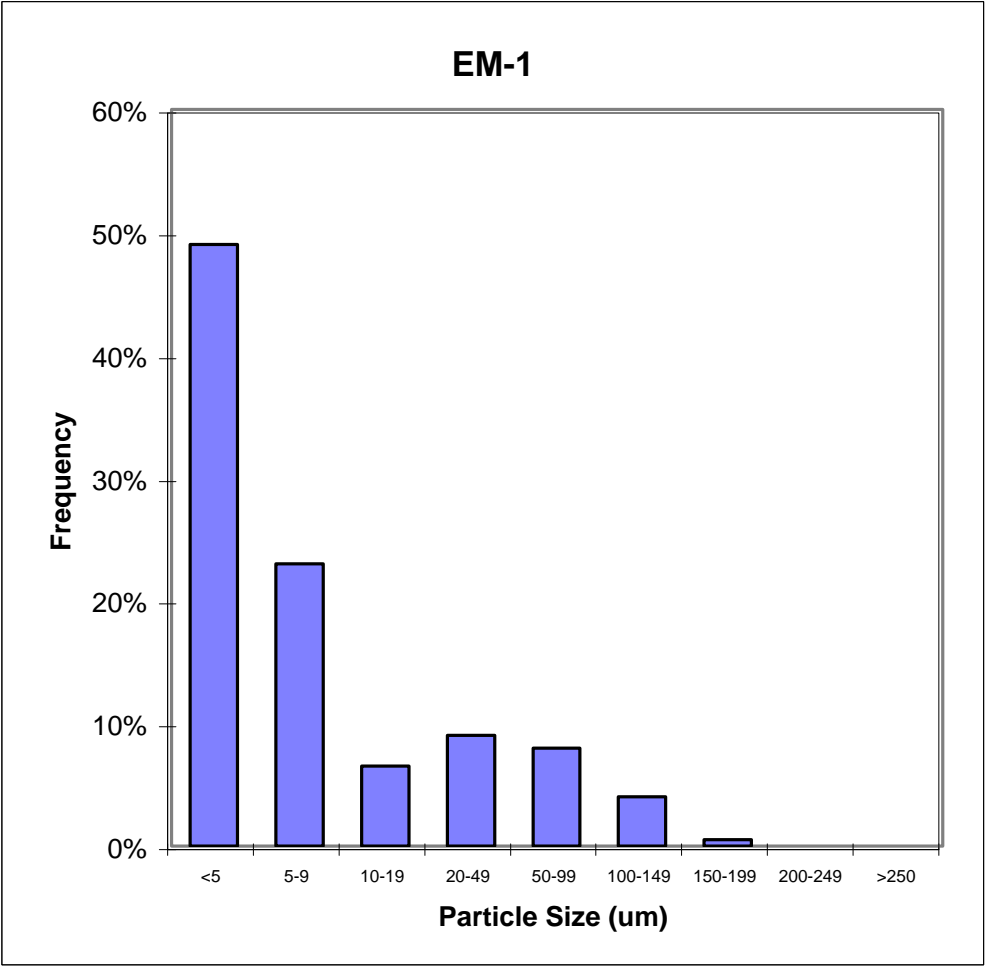
FIGURE 1 PARTICLE SIZE DISTRIBUTION

EM-1

RELATIVE ARSENIC MASS
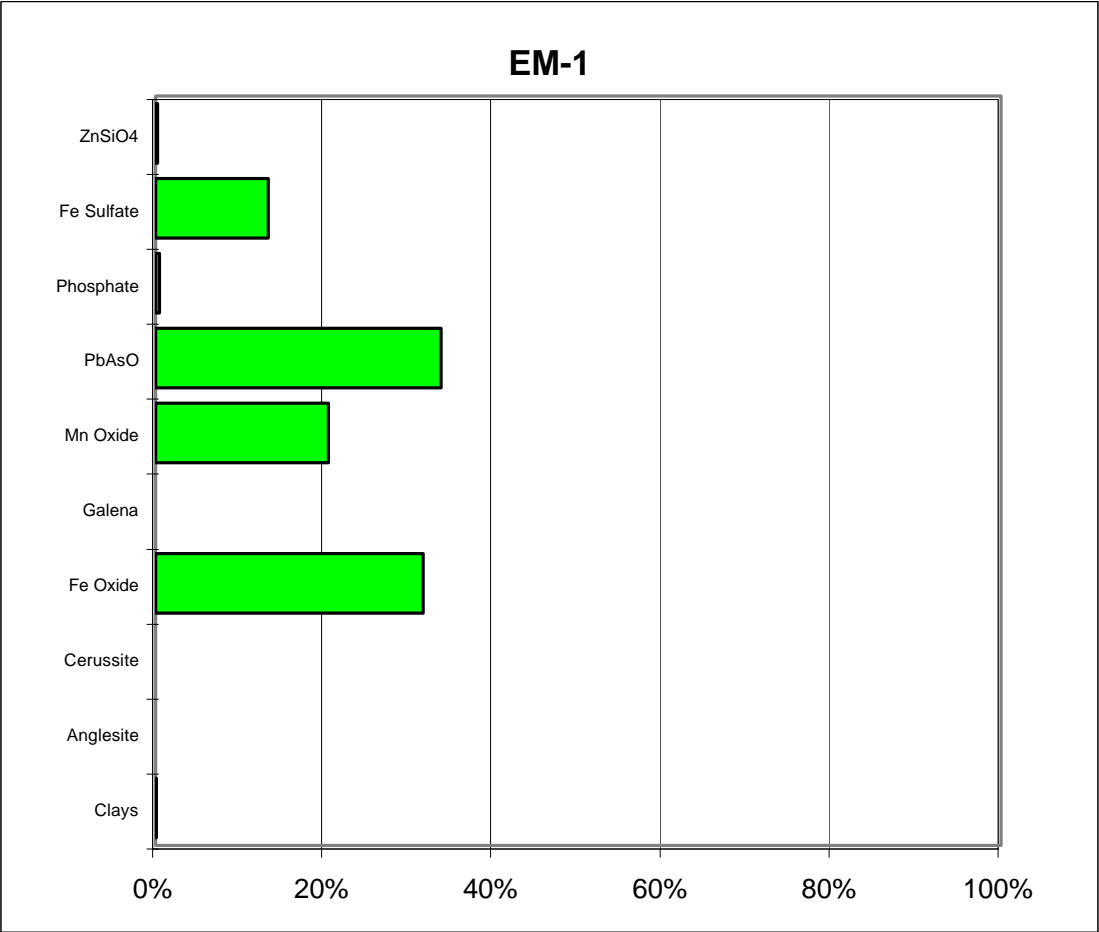
RELATIVE LEAD MASS
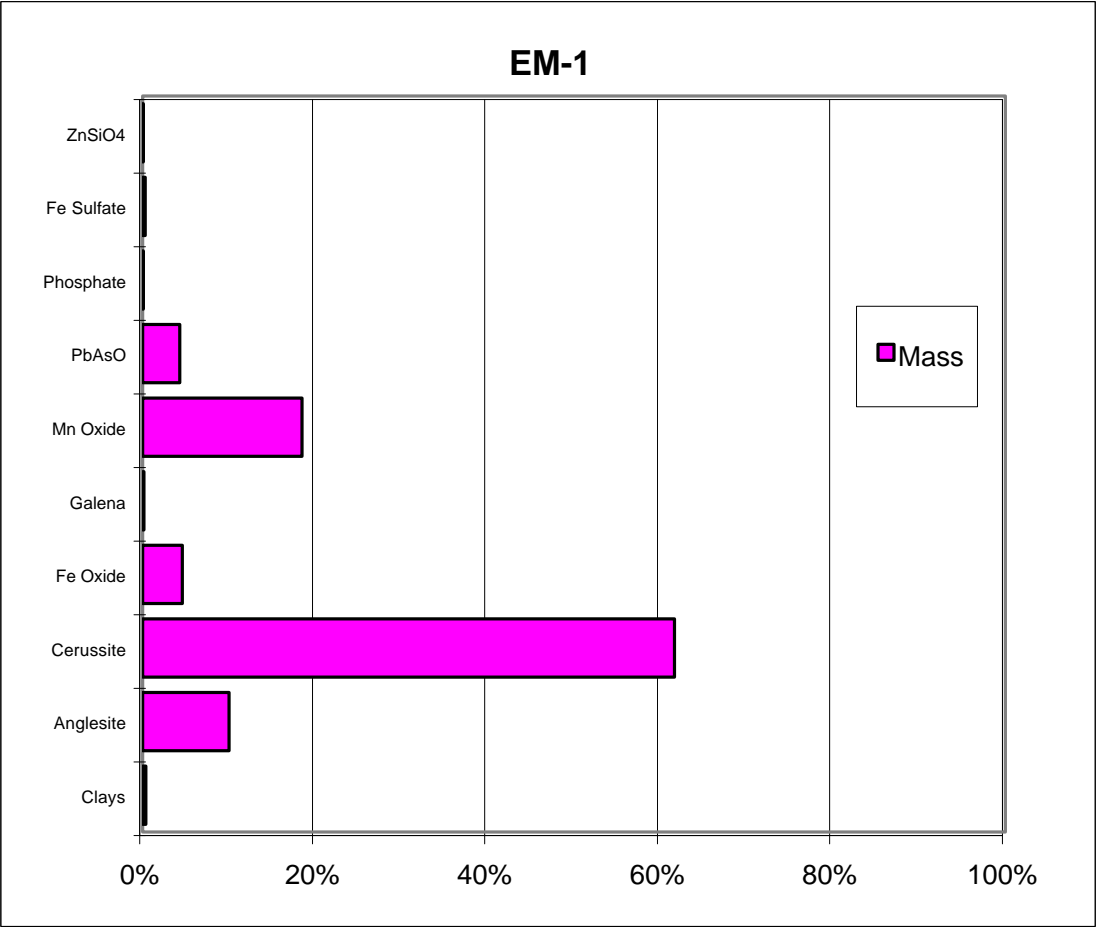
Mineral	Arsenic Freq	Arsenic Mass	Lead Freq	Lead Mass
Clays	2.4%	0.04%	2.4%	0.4%
Anglesite	3.4%	0.00%	3.4%	10.0%
Cerussite	17.6%	0.00%	17.6%	61.6%
Fe Oxide	36.1%	31.67%	36.1%	4.6%
Galena	0.0%	0.00%	0.0%	0.1%
Mn Oxide	28.1%	20.45%	28.1%	18.5%
PbAsO	1.4%	33.78%	1.4%	4.3%
Phosphate	0.5%	0.47%	0.5%	0.1%
Fe Sulfate	9.0%	13.34%	9.0%	0.3%
ZnSiO4	1.3%	0.24%	1.3%	0.0%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	49.0%	49.0%
5-9	23.0%	23.0%
10-19	6.5%	6.5%
20-49	9.0%	9.0%
50-99	8.0%	8.0%
100-149	4.0%	4.0%
150-199	0.5%	0.5%
200-249	0.0%	0.0%
≥250	0.0%	0.0%

SAMPLE ID EM-02

SUMMARY STATISTICS

EM-2 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract As	Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated			Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	67	66	18	0	80	20.4%	20.1%	20.83%	20.21%	6.6	0	0.0%	0.0%	<5	49.1%	49.1%	9.1%	9.1%
Fe Oxide	205	205	15	2	165	62.5%	62.5%	54.83%	54.83%	4	0.011	60.4%	60.4%	5-9	14.6%	14.3%	7.1%	3.3%
Mn Oxide	15	15	30	8	115	4.6%	4.6%	7.99%	7.99%	5	0.0073	7.3%	7.3%	10-19	12.2%	12.2%	6.4%	6.4%
PbAsO	1	0	7	7	7	0.3%	0.0%	0.12%	0.00%	7.1	0.17	3.7%	0.0%	20-49	12.2%	11.9%	14.0%	14.0%
Phosphate	7	7	19	10	50	2.1%	2.1%	2.38%	2.38%	5	0.0093	2.8%	2.8%	50-99	8.2%	8.2%	34.4%	34.4%
Pyrite	3	3	32	12	50	0.9%	0.9%	1.71%	1.71%	4.8	0.016	3.3%	3.3%	100-149	3.4%	3.4%	25.8%	25.8%
Fe Sulfate	30	30	23	3	110	9.1%	9.1%	12.13%	12.13%	3.7	0.02	22.5%	22.5%	150-199	0.3%	0.3%	3.2%	3.2%
														200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	99%	100%	96%
TOTAL	328	326	17			100.0%	99.4%	100.00%	99.26%			100.0%	96.3%					

SUMMARY STATISTICS

EM-2 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract Pb	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	67	66	18	0	80	20.4%	20.1%	20.83%	20.21%	6.6	0.776	84.4%	81.9%	<5	49.1%	49.1%	2.1%	2.1%
Fe Oxide	205	205	15	2	165	62.5%	62.5%	54.83%	54.83%	4	0.047	8.2%	8.2%	5-9	14.6%	14.3%	10.3%	9.9%
Mn Oxide	15	15	30	8	115	4.6%	4.6%	7.99%	7.99%	5	0.193	6.1%	6.1%	10-19	12.2%	12.2%	14.9%	14.9%
PbAsO	1	0	7	7	7	0.3%	0.0%	0.12%	0.00%	7.1	0.633	0.4%	0.0%	20-49	12.2%	11.9%	45.6%	43.1%
Phosphate	7	7	19	10	50	2.1%	2.1%	2.38%	2.38%	5	0.037	0.3%	0.3%	50-99	8.2%	8.2%	22.6%	22.6%
Pyrite	3	3	32	12	50	0.9%	0.9%	1.71%	1.71%	4.8	0.00007	0.0%	0.0%	100-149	3.4%	3.4%	4.0%	4.0%
Fe Sulfate	30	30	23	3	110	9.1%	9.1%	12.13%	12.13%	3.7	0.0146	0.5%	0.5%	150-199	0.3%	0.3%	0.4%	0.4%
														200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	99%	100%	97%

# MINERAL FREQUENCY OBSERVED IN SITE SOIL
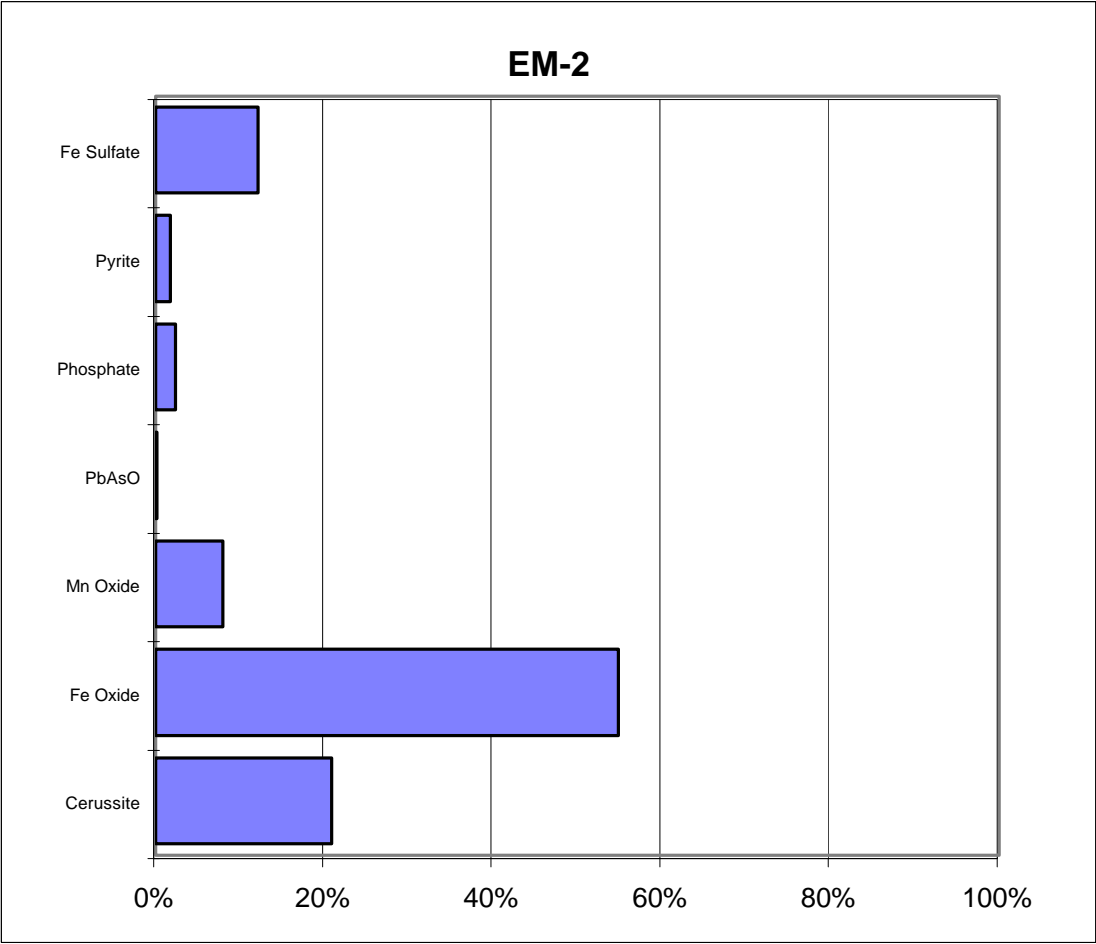
EM-2

FIGURE 1 PARTICLE SIZE DISTRIBUTION

EM-2
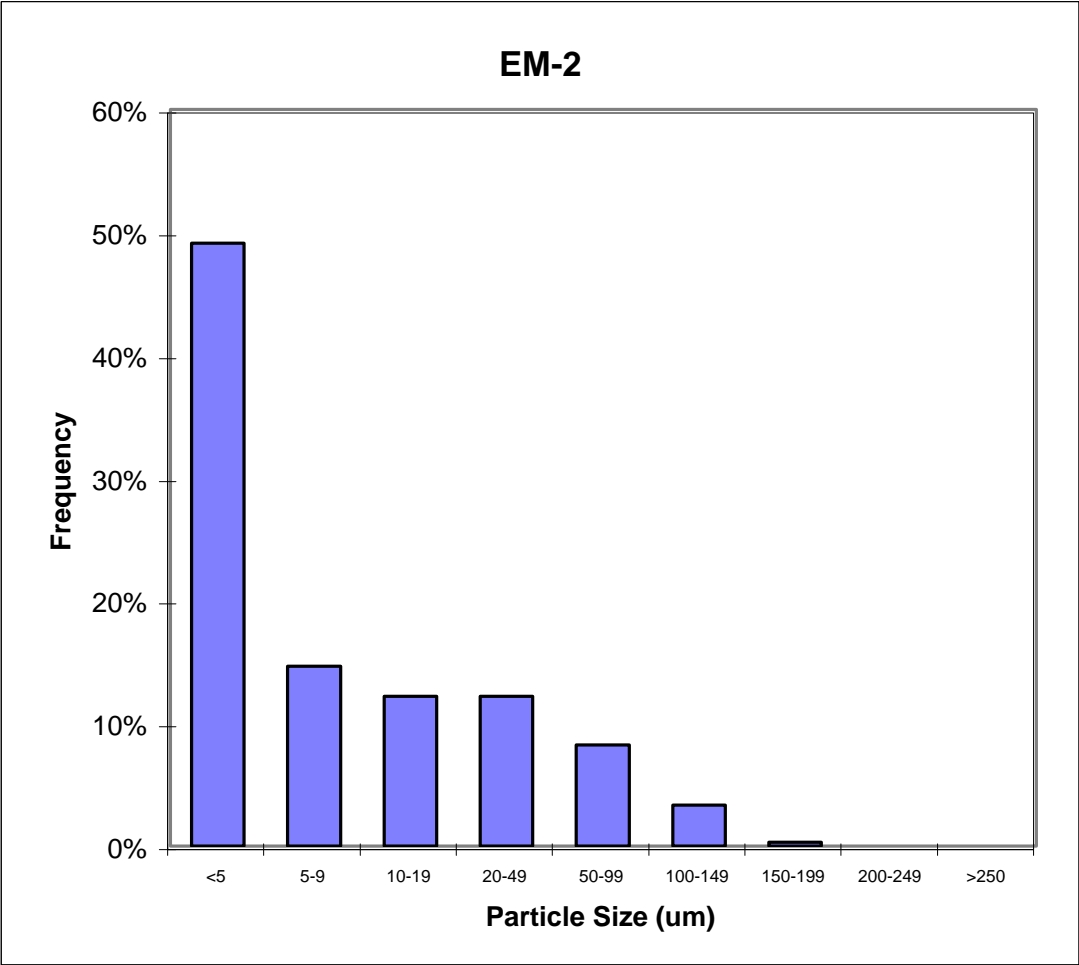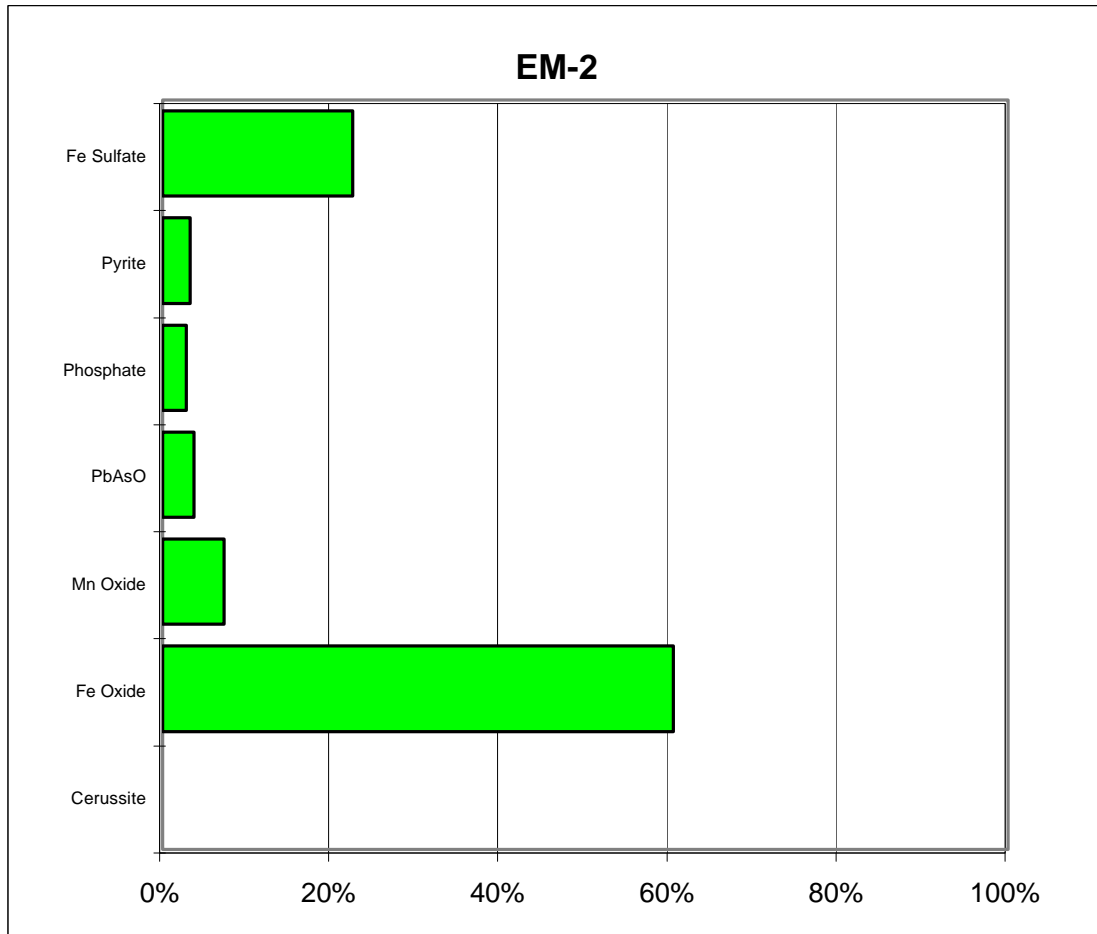
RELATIVE ARSENIC MASS

RELATIVE LEAD MASS
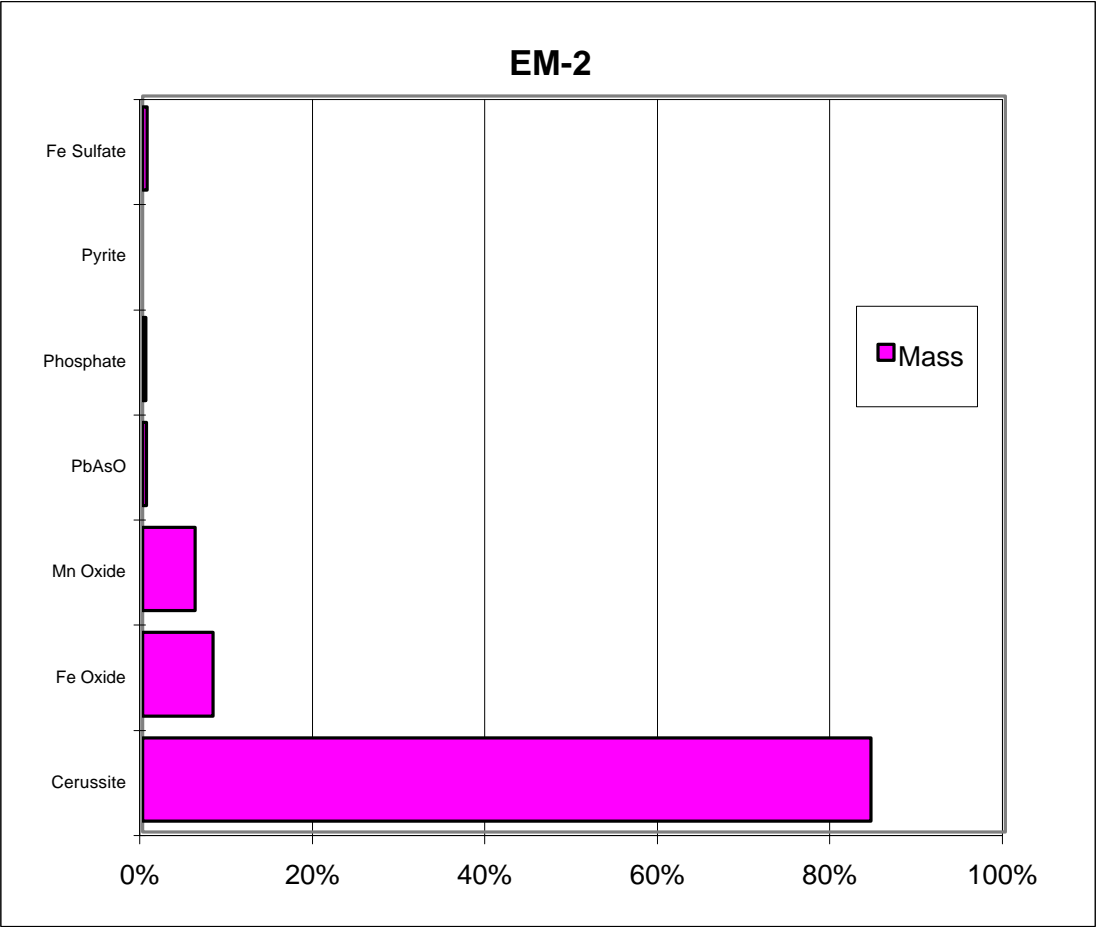
EM-2

Mineral	Arsenic Freq	Arsenic Mass	Lead Freq	Lead Mass
Cerussite	20.8%	0.00%	20.8%	84.4%
Fe Oxide	54.8%	60.42%	54.8%	8.2%
Mn Oxide	8.0%	7.30%	8.0%	6.1%
PbAsO	0.1%	3.73%	0.1%	0.4%
Phosphate	2.4%	2.77%	2.4%	0.3%
Pyrite	1.7%	3.29%	1.7%	0.0%
Fe Sulfate	12.1%	22.49%	12.1%	0.5%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	49.1%	49.1%
5-9	14.6%	14.6%
10-19	12.2%	12.2%
20-49	12.2%	12.2%
50-99	8.2%	8.2%
100-149	3.4%	3.4%
150-199	0.3%	0.3%
200-249	0.0%	0.0%
≥250	0.0%	0.0%

SAMPLE ID EM-03

SUMMARY STATISTICS

EM-3 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract As	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	19	19	26	2	85	16.2%	16.2%	20.91%	20.91%	6.6	0	0.0%	0.0%	<5	36.8%	12.8%	1.7%	1.6%
Fe Oxide	17	17	41	8	100	14.5%	14.5%	29.47%	29.47%	4	0.011	28.9%	28.9%	5-9	15.4%	9.4%	2.0%	2.0%
Galena	32	0	5	1	52	27.4%	0.0%	6.20%	0.00%	7.5	0	0.0%	0.0%	10-19	20.5%	18.8%	24.4%	24.4%
Mn Oxide	3	3	44	40	50	2.6%	2.6%	5.56%	5.56%	5	0.0073	4.5%	4.5%	20-49	15.4%	15.4%	23.5%	23.5%
PbAsO	1	1	10	10	10	0.9%	0.9%	0.42%	0.42%	7.1	0.17	11.3%	11.3%	50-99	9.4%	8.5%	25.7%	25.7%
Phosphate	19	13	14	1	46	16.2%	11.1%	10.92%	9.95%	5	0.0093	11.3%	10.3%	100-149	2.6%	2.6%	22.7%	22.7%
Pyrite	2	2	67	18	115	1.7%	1.7%	5.61%	5.61%	4.8	0.016	9.6%	9.6%	150-199	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	24	24	21	3	140	20.5%	20.5%	20.91%	20.91%	3.7	0.02	34.4%	34.4%	200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	68%	100%	100%
TOTAL	117	79	20			100.0%	67.5%	100.00%	92.83%			100.0%	99.0%					

SUMMARY STATISTICS

EM-3 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract Pb	Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract Pb	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	19	19	26	2	85	16.2%	16.2%	20.91%	20.91%	6.6	0.776	65.6%	65.6%	<5	36.8%	12.8%	7.6%	0.5%
Fe Oxide	17	17	41	8	100	14.5%	14.5%	29.47%	29.47%	4	0.047	3.4%	3.4%	5-9	15.4%	9.4%	9.2%	3.8%
Galena	32	0	5	1	52	27.4%	0.0%	6.20%	0.00%	7.5	0.866	24.6%	0.0%	10-19	20.5%	18.8%	18.7%	15.2%
Mn Oxide	3	3	44	40	50	2.6%	2.6%	5.56%	5.56%	5	0.193	3.3%	3.3%	20-49	15.4%	15.4%	24.0%	24.0%
PbAsO	1	1	10	10	10	0.9%	0.9%	0.42%	0.42%	7.1	0.633	1.2%	1.2%	50-99	9.4%	8.5%	40.0%	31.7%
Phosphate	19	13	14	1	46	16.2%	11.1%	10.92%	9.95%	5	0.037	1.2%	1.1%	100-149	2.6%	2.6%	0.6%	0.6%
Pyrite	2	2	67	18	115	1.7%	1.7%	5.61%	5.61%	4.8	0.00007	0.0%	0.0%	150-199	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	24	24	21	3	140	20.5%	20.5%	20.91%	20.91%	3.7	0.0146	0.7%	0.7%	200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	68%	100%	76%

MINERAL FREQUENCY OBSERVED IN SITE SOIL
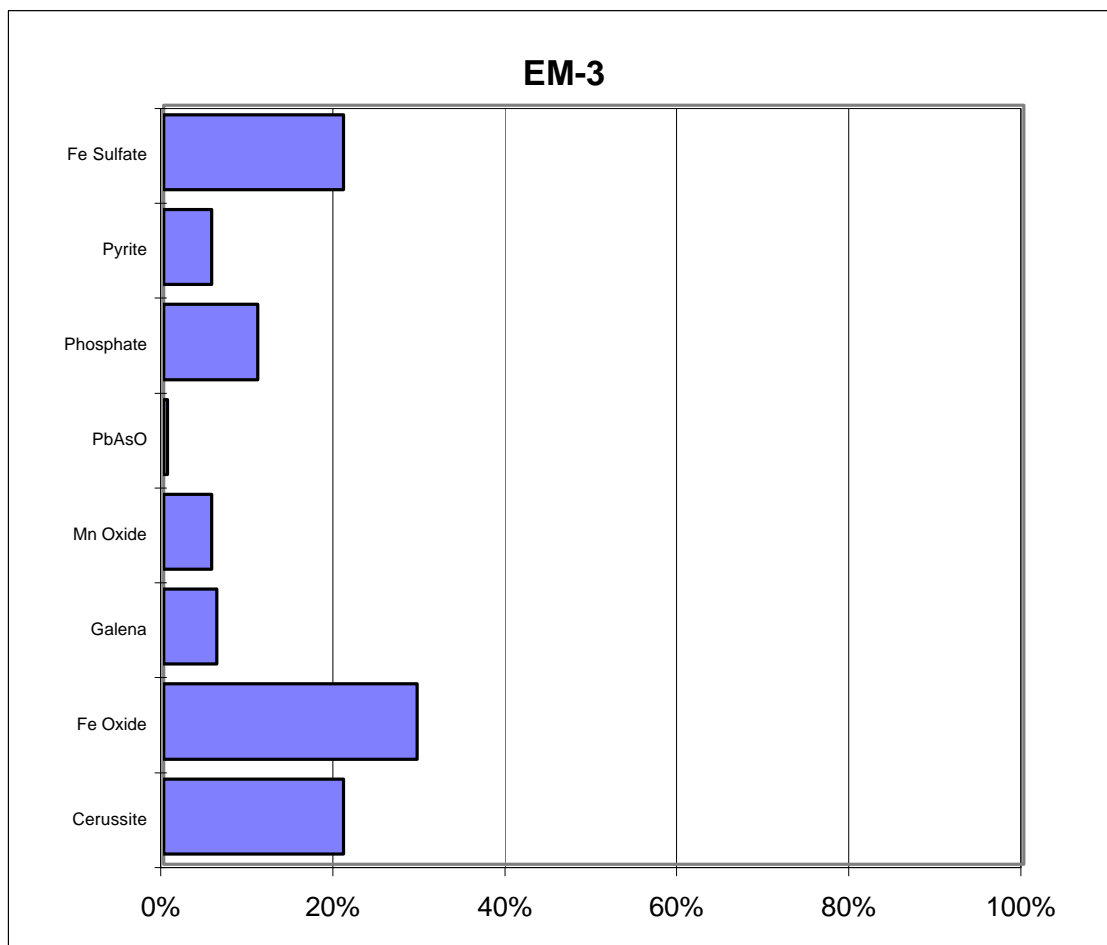
EM-3

FIGURE 1 PARTICLE SIZE DISTRIBUTION

EM-3

RELATIVE ARSENIC MASS

EM-3

RELATIVE LEAD MASS

EM-3
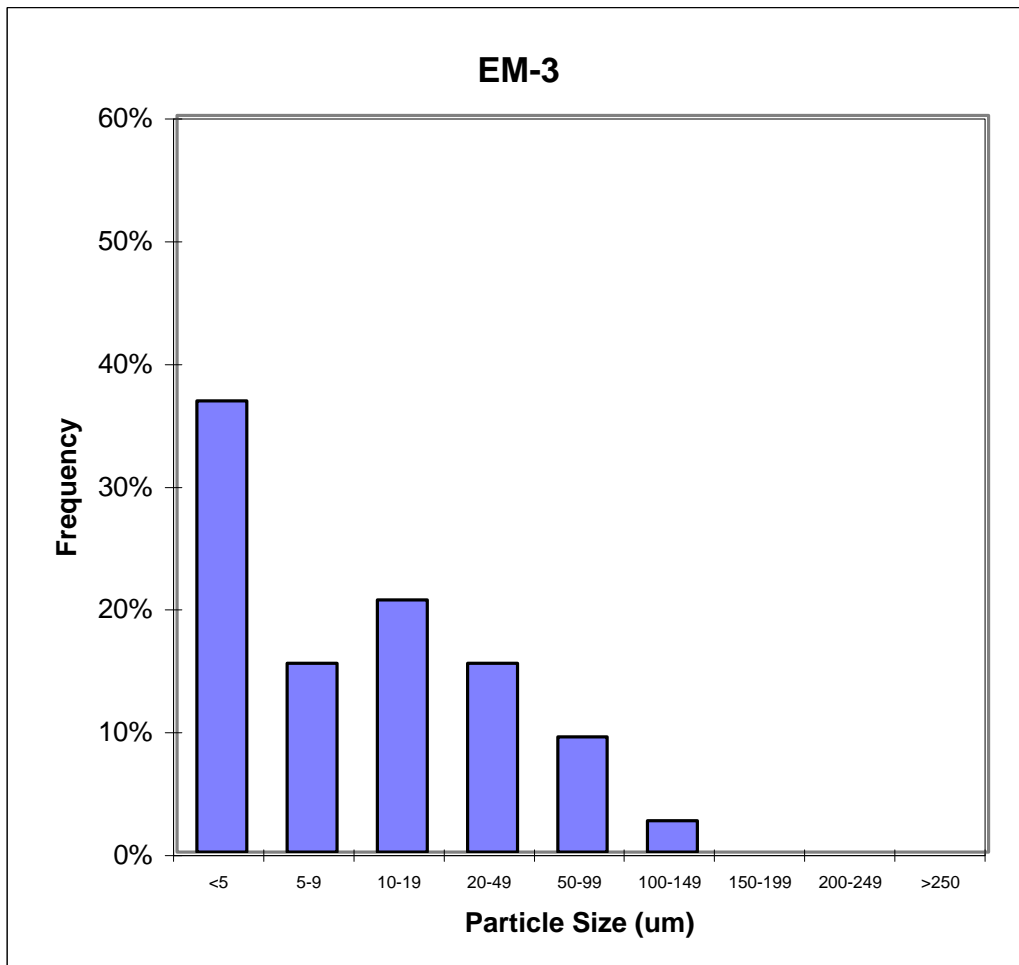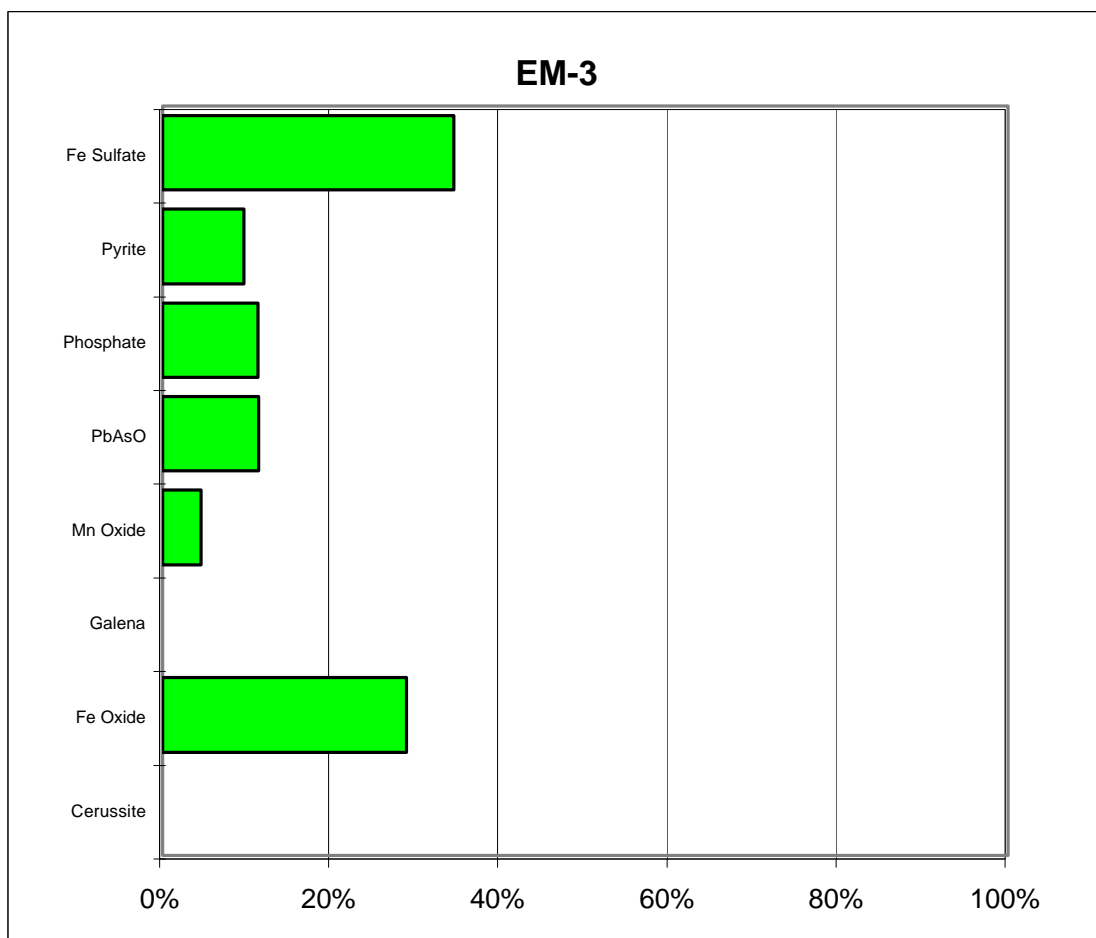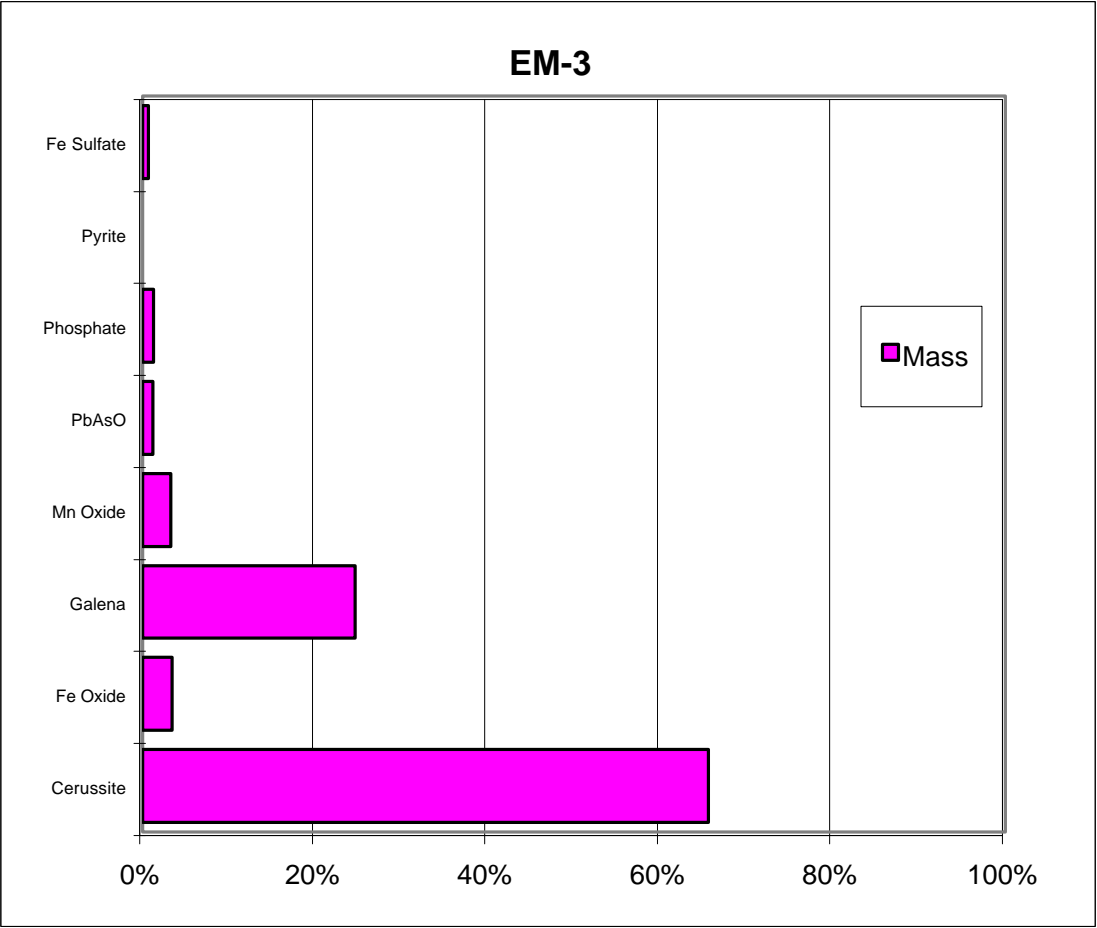
EM-3

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Cerussite	20.9%	0.00%	20.9%	65.6%
Fe Oxide	29.5%	28.85%	29.5%	3.4%
Galena	6.2%	0.00%	6.2%	24.6%
Mn Oxide	5.6%	4.52%	5.6%	3.3%
PbAsO	0.4%	11.32%	0.4%	1.2%
Phosphate	10.9%	11.30%	10.9%	1.2%
Pyrite	5.6%	9.58%	5.6%	0.0%
Fe Sulfate	20.9%	34.43%	20.9%	0.7%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	36.8%	36.8%
5-9	15.4%	15.4%
10-19	20.5%	20.5%
20-49	15.4%	15.4%
50-99	9.4%	9.4%
100-149	2.6%	2.6%
150-199	0.0%	0.0%
200-249	0.0%	0.0%
≥250	0.0%	0.0%

SAMPLE ID EM-04

SUMMARY STATISTICS

EM-4 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract As	Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract As	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Anglesite	3	3	5	1	8	2.4%	2.4%	0.41%	0.41%	6.3	0	0.0%	0.0%	<5	23.2%	11.2%	1.5%	1.0%
Cerussite	24	21	21	1	105	19.2%	16.8%	14.61%	12.58%	6.6	0	0.0%	0.0%	5-9	16.0%	16.0%	11.1%	11.1%
Fe Oxide	44	44	48	7	138	35.2%	35.2%	61.50%	61.50%	4	0.011	64.4%	64.4%	10-19	15.2%	13.6%	5.1%	4.7%
Galena	4	0	1	1	1	3.2%	0.0%	0.12%	0.00%	7.5	0	0.0%	0.0%	20-49	26.4%	26.4%	28.1%	28.1%
Mn Oxide	13	13	24	7	85	10.4%	10.4%	8.98%	8.98%	5	0.0073	7.8%	7.8%	50-99	12.0%	11.2%	24.8%	24.8%
PbAsO	1	1	9	9	9	0.8%	0.8%	0.26%	0.26%	7.1	0.17	7.5%	7.5%	100-149	7.2%	7.2%	29.4%	29.4%
PbSiO4	1	1	26	26	26	0.8%	0.8%	0.76%	0.76%	6	0	0.0%	0.0%	150-199	0.0%	0.0%	0.0%	0.0%
Phosphate	15	13	12	2	32	12.0%	10.4%	5.03%	4.56%	5	0.0093	5.6%	5.0%	200-249	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	20	11	14	1	112	16.0%	8.8%	8.34%	8.08%	3.7	0.02	14.7%	14.2%	≥250	0.0%	0.0%	0.0%	0.0%
															100%	86%	100%	99%
TOTAL	125	107	28			100.0%	85.6%	100.00%	97.12%			100.0%	99.0%					

SUMMARY STATISTICS

EM-4 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract Pb	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Anglesite	3	3	5	1	8	2.4%	2.4%	0.41%	0.41%	6.3	0.684	1.7%	1.7%	<5	23.2%	11.2%	3.3%	2.1%
Cerussite	24	21	21	1	105	19.2%	16.8%	14.61%	12.58%	6.6	0.776	73.1%	62.9%	5-9	16.0%	16.0%	7.1%	7.1%
Fe Oxide	44	44	48	7	138	35.2%	35.2%	61.50%	61.50%	4	0.047	11.3%	11.3%	10-19	15.2%	13.6%	15.4%	13.6%
Galena	4	0	1	1	1	3.2%	0.0%	0.12%	0.00%	7.5	0.866	0.7%	0.0%	20-49	26.4%	26.4%	18.2%	18.2%
Mn Oxide	13	13	24	7	85	10.4%	10.4%	8.98%	8.98%	5	0.193	8.5%	8.5%	50-99	12.0%	11.2%	36.4%	28.5%
PbAsO	1	1	9	9	9	0.8%	0.8%	0.26%	0.26%	7.1	0.633	1.1%	1.1%	100-149	7.2%	7.2%	19.6%	19.6%
PbSiO4	1	1	26	26	26	0.8%	0.8%	0.76%	0.76%	6	0.5	2.2%	2.2%	150-199	0.0%	0.0%	0.0%	0.0%
Phosphate	15	13	12	2	32	12.0%	10.4%	5.03%	4.56%	5	0.037	0.9%	0.8%	200-249	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	20	11	14	1	112	16.0%	8.8%	8.34%	8.08%	3.7	0.0146	0.4%	0.4%	≥250	0.0%	0.0%	0.0%	0.0%
															100%	86%	100%	89%

# MINERAL FREQUENCY OBSERVED IN SITE SOIL

EM-4

FIGURE 1 PARTICLE SIZE DISTRIBUTION

EM-4

RELATIVE ARSENIC MASS

EM-4
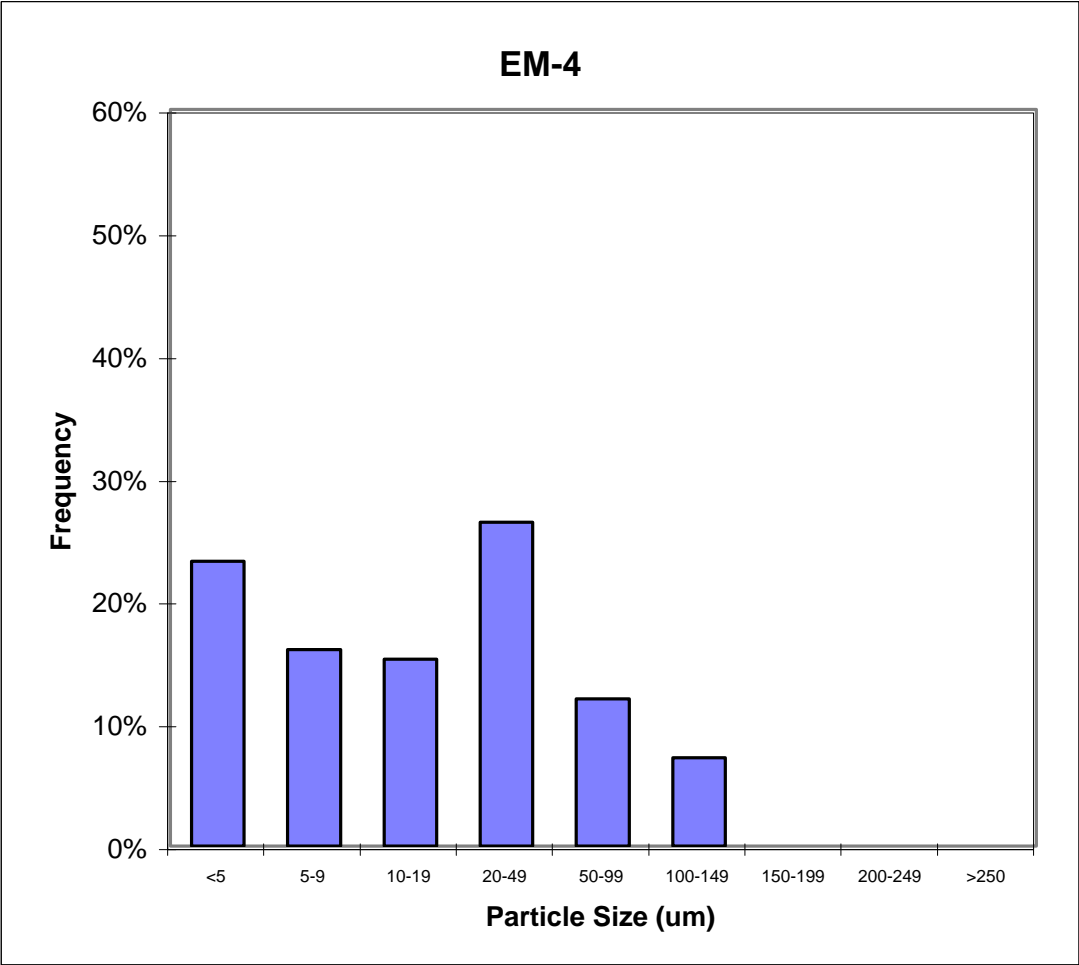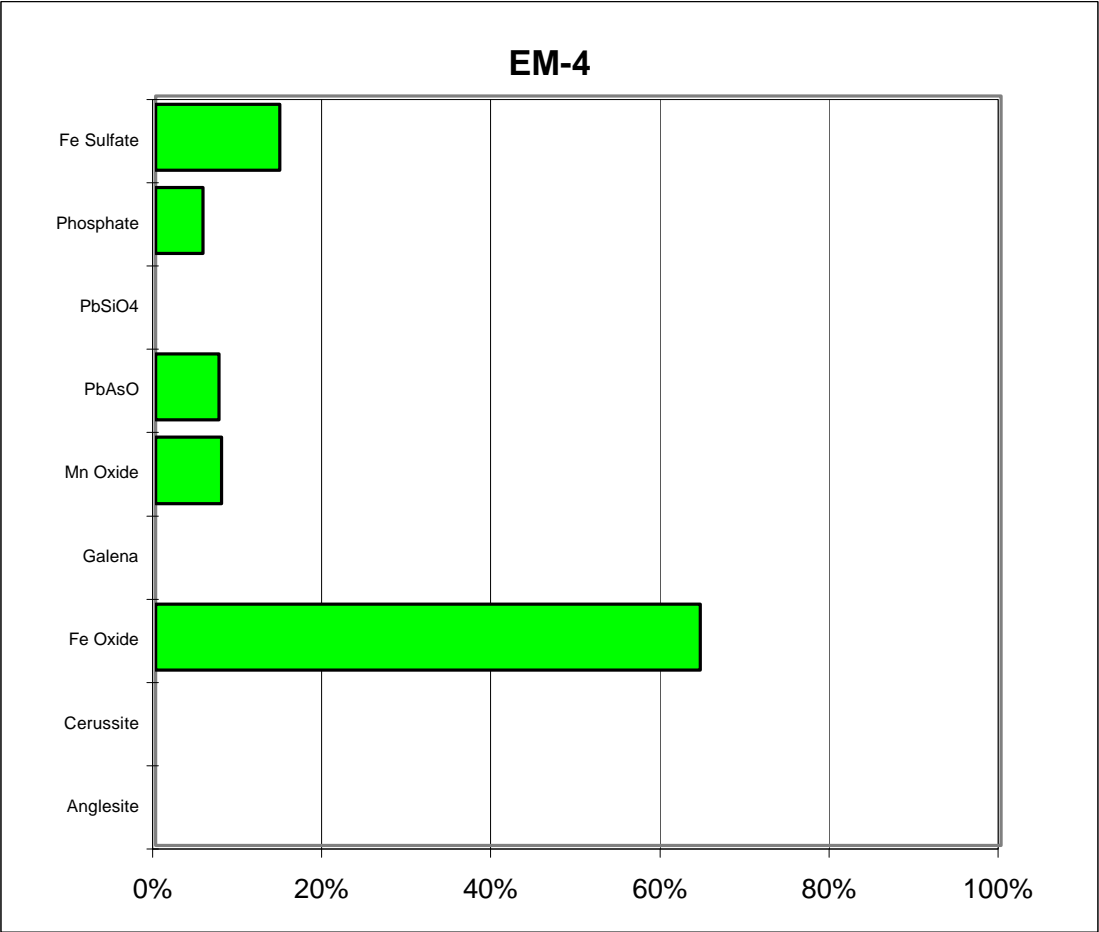
RELATIVE LEAD MASS
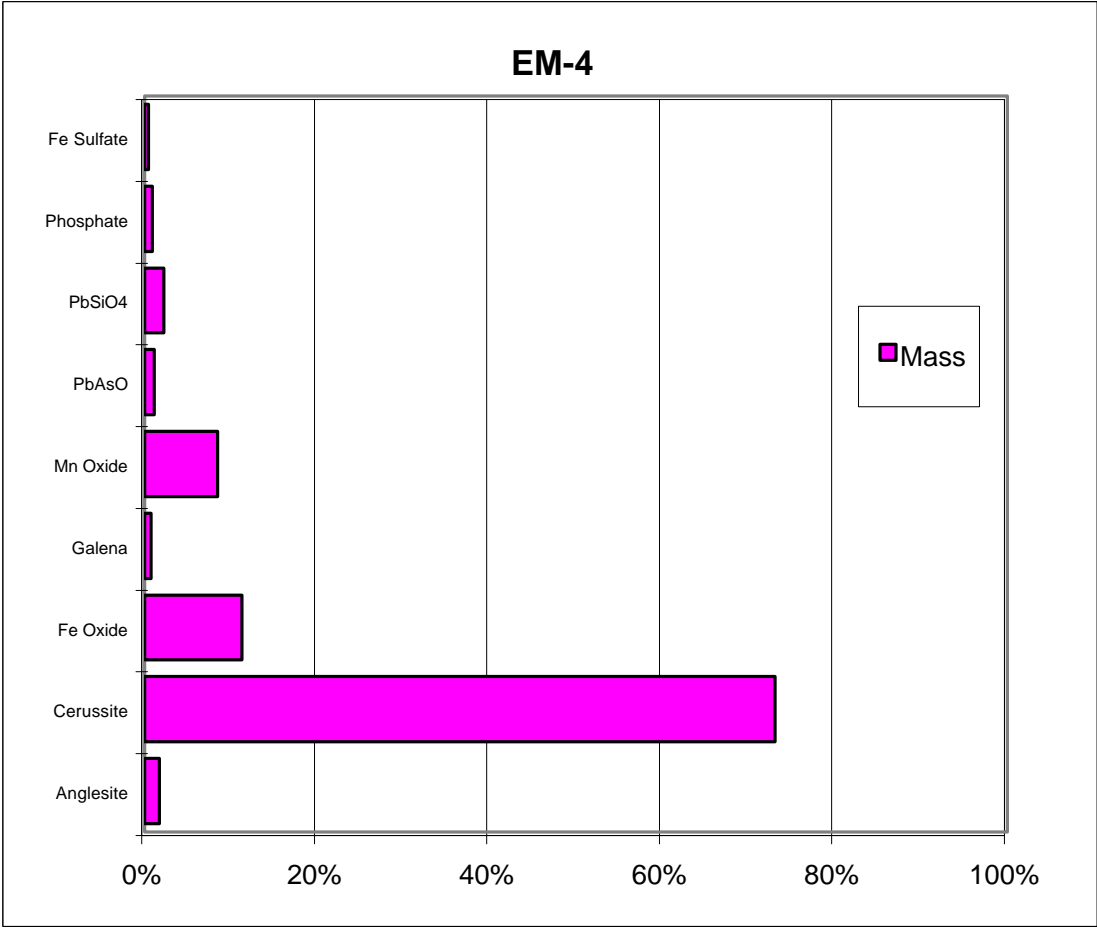
EM-4

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Anglesite	0.4%	0.00%	0.4%	1.7%
Cerussite	14.6%	0.00%	14.6%	73.1%
Fe Oxide	61.5%	64.43%	61.5%	11.3%
Galena	0.1%	0.00%	0.1%	0.7%
Mn Oxide	9.0%	7.80%	9.0%	8.5%
PbAsO	0.3%	7.51%	0.3%	1.1%
PbSiO4	0.8%	0.00%	0.8%	2.2%
Phosphate	5.0%	5.56%	5.0%	0.9%
Fe Sulfate	8.3%	14.69%	8.3%	0.4%

Size	Arsenic	Lead
<5	23.2%	23.2%
5-9	16.0%	16.0%
10-19	15.2%	15.2%
20-49	26.4%	26.4%
50-99	12.0%	12.0%
100-149	7.2%	7.2%
150-199	0.0%	0.0%
200-249	0.0%	0.0%
≥250	0.0%	0.0%

Total 100%   100%   100%   100%

SAMPLE ID EM-05

SUMMARY STATISTICS

EM-5 - Arsenic

Mineral	COUNTS Total	Lib	Avg	SIZE Min	Max	Count Freq (%) Total	Liberated	LW Freq (%) Total	Liberated	Density	Fract As	Relative Arsenic Mass (%) Total	Liberated	Size	DISTRIBUTION Total Freq	Lib Freq	Total RAM	Lib RAM
Anglesite	3	3	35	11	70	2.4%	2.4%	4.02%	4.02%	6.3	0	0.0%	0.0%	<5	39.8%	25.2%	#DIV/0!	#DIV/0!
Cerussite	25	22	12	1	75	20.3%	17.9%	11.32%	8.34%	6.6	0	0.0%	0.0%	5-9	12.2%	11.4%	#DIV/0!	#DIV/0!
Fe Oxide	25	25	41	3	110	20.3%	20.3%	38.83%	38.83%	4	0.011	32.3%	32.3%	10-19	11.4%	11.4%	#DIV/0!	#DIV/0!
Galena	14	1	1	1	2	11.4%	0.8%	0.73%	0.08%	7.5	0	0.0%	0.0%	20-49	20.3%	15.4%	#DIV/0!	#DIV/0!
Mn Oxide	2	2	13	9	16	1.6%	1.6%	0.96%	0.96%	5	0.0073	0.7%	0.7%	50-99	13.8%	13.0%	#DIV/0!	#DIV/0!
PbAsO	5	5	13	3	29	4.1%	4.1%	2.45%	2.45%	7.1	0.17	55.9%	55.9%	100-149	2.4%	2.4%	#DIV/0!	#DIV/0!
Phosphate	34	24	22	3	105	27.6%	19.5%	29.04%	23.79%	6	0	0.0%	0.0%	150-199	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	15	15	22	2	75	12.2%	12.2%	12.66%	12.66%	5	0.0093	11.1%	11.1%	200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	79%	#DIV/0!	#DIV/0!
TOTAL	123	97	21			100.0%	78.9%	100.00%	91.12%			100.0%	100.0%					

SUMMARY STATISTICS

EM-5 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Lead Mass (%)			DISTRIBUTION			
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract Pb	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Anglesite	3	3	35	11	70	2.4%	2.4%	4.02%	4.02%	6.3	0.684	9.2%	9.2%	<5	39.8%	25.2%	4.5%	3.3%
Cerussite	25	22	12	1	75	20.3%	17.9%	11.32%	8.34%	6.6	0.776	30.7%	22.6%	5-9	12.2%	11.4%	4.1%	3.8%
Fe Oxide	25	25	41	3	110	20.3%	20.3%	38.83%	38.83%	4	0.047	3.9%	3.9%	10-19	11.4%	11.4%	6.3%	6.3%
Galena	14	1	1	1	2	11.4%	0.8%	0.73%	0.08%	7.5	0.866	2.5%	0.3%	20-49	20.3%	15.4%	26.6%	21.8%
Mn Oxide	2	2	13	9	16	1.6%	1.6%	0.96%	0.96%	5	0.193	0.5%	0.5%	50-99	13.8%	13.0%	46.3%	43.6%
PbAsO	5	5	13	3	29	4.1%	4.1%	2.45%	2.45%	7.1	0.633	5.8%	5.8%	100-149	2.4%	2.4%	12.2%	12.2%
Phosphate	34	24	22	3	105	27.6%	19.5%	29.04%	23.79%	6	0.5	46.2%	37.8%	150-199	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	15	15	22	2	75	12.2%	12.2%	12.66%	12.66%	5	0.037	1.2%	1.2%	200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	79%	100%	91%

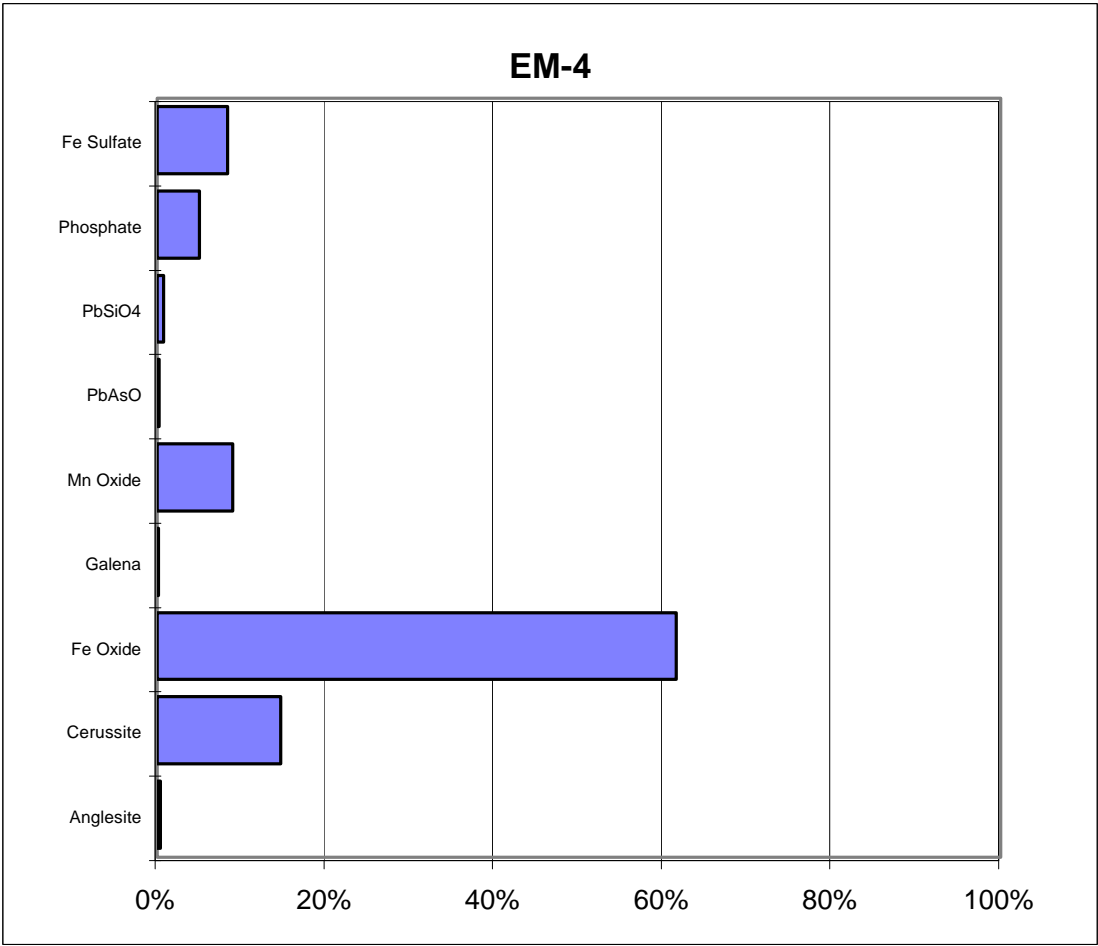# MINERAL FREQUENCY OBSERVED IN SITE SOIL
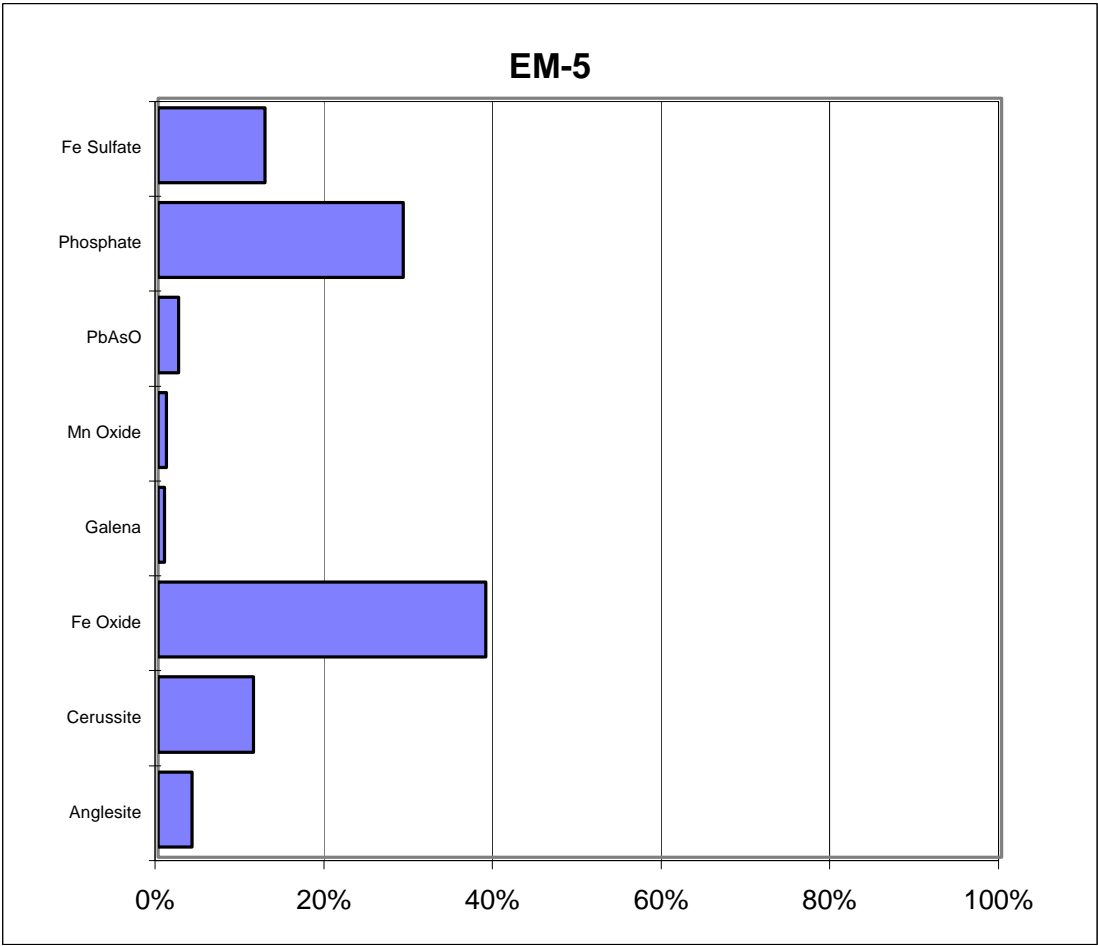
EM-5

FIGURE 1 PARTICLE SIZE DISTRIBUTION

RELATIVE ARSENIC MASS

EM-5
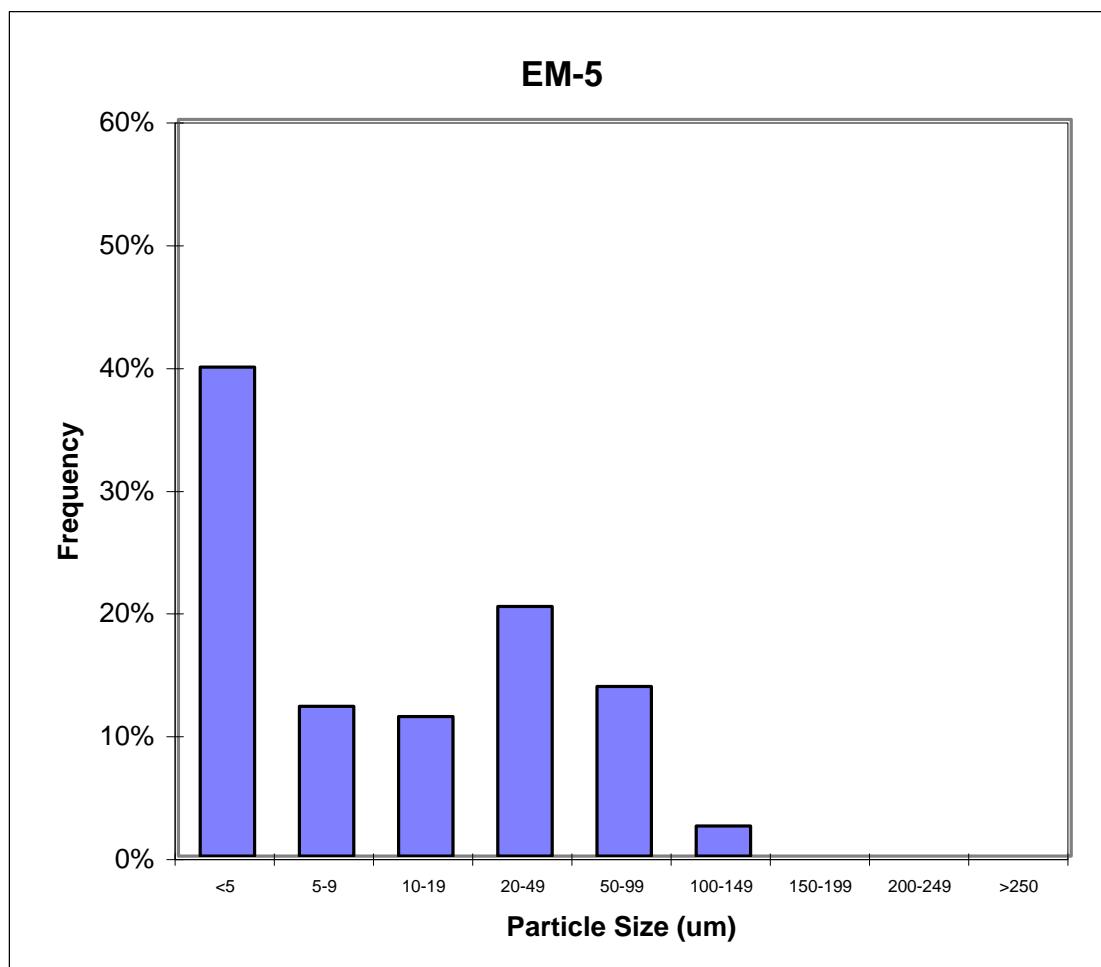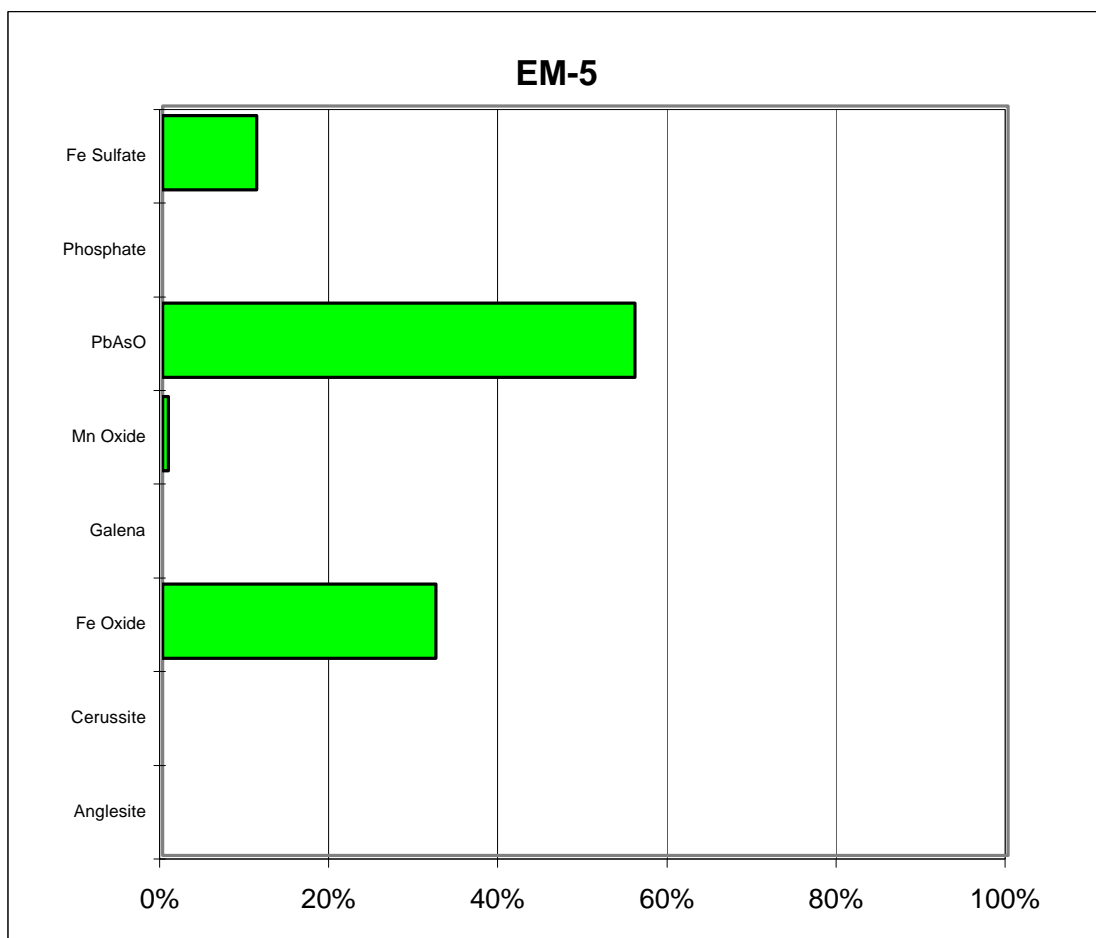
RELATIVE LEAD MASS
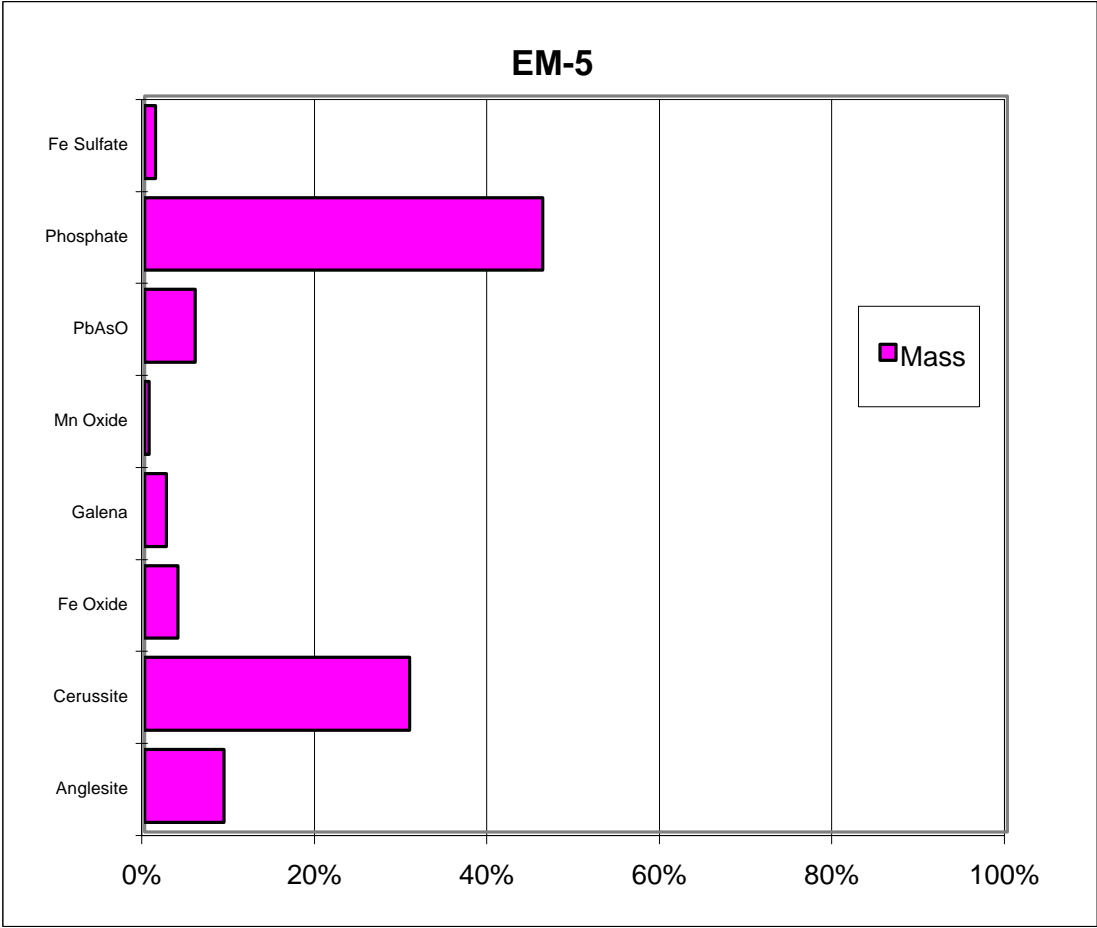
EM-5

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Anglesite	4.0%	0.00%	4.0%	9.2%
Cerussite	11.3%	0.00%	11.3%	30.7%
Fe Oxide	38.8%	32.31%	38.8%	3.9%
Galena	0.7%	0.00%	0.7%	2.5%
Mn Oxide	1.0%	0.66%	1.0%	0.5%
PbAsO	2.4%	55.89%	2.4%	5.8%
Phosphate	29.0%	0.00%	29.0%	46.2%
Fe Sulfate	12.7%	11.14%	12.7%	1.2%

Size	Arsenic	Lead
<5	39.8%	39.8%
5-9	12.2%	12.2%
10-19	11.4%	11.4%
20-49	20.3%	20.3%
50-99	13.8%	13.8%
100-149	2.4%	2.4%
150-199	0.0%	0.0%
200-249	0.0%	0.0%
≥250	0.0%	0.0%

| **Total** | 100% | 100% | 100% | 100% |

SAMPLE ID EM-06

SUMMARY STATISTICS
EM-6 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract As	Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract As	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Clays	2	2	44	40	48	1.4%	1.4%	2.92%	2.92%	3.1	0.00028	0.1%	0.1%	<5	26.9%	24.8%	1.3%	1.3%
Anglesite	5	5	5	4	10	3.4%	3.4%	0.86%	0.86%	6.3	0	0.0%	0.0%	5-9	17.9%	17.9%	3.0%	3.0%
Barite	1	1	10	10	10	0.7%	0.7%	0.33%	0.33%	4.5	0	0.0%	0.0%	10-19	21.4%	21.4%	9.4%	9.4%
Cerussite	61	59	8	1	38	42.1%	40.7%	16.89%	16.82%	6.6	0	0.0%	0.0%	20-49	24.1%	23.4%	33.6%	33.6%
Fe Oxide	41	41	31	4	205	28.3%	28.3%	42.60%	42.60%	4	0.011	48.1%	48.1%	50-99	7.6%	7.6%	36.2%	36.2%
Galena	2	0	11	1	20	1.4%	0.0%	0.70%	0.00%	7.5	0	0.0%	0.0%	100-149	1.4%	1.4%	8.8%	8.8%
Mn Oxide	9	9	36	11	80	6.2%	6.2%	10.78%	10.78%	5	0.0073	10.1%	10.1%	150-199	0.0%	0.0%	0.0%	0.0%
Phosphate	6	6	40	6	105	4.1%	4.1%	7.93%	7.93%	5	0.0093	9.5%	9.5%	200-249	0.7%	0.7%	7.7%	7.7%
Pyrite	4	4	13	6	20	2.8%	2.8%	1.66%	1.66%	4.8	0.016	3.3%	3.3%	≥250	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	14	14	33	1	96	9.7%	9.7%	15.33%	15.33%	3.7	0.02	29.1%	29.1%					
															100%	97%	100%	100%
TOTAL	145	141	21			100.0%	97.2%	100.00%	99.24%			100.0%	100.0%					

SUMMARY STATISTICS
EM-6 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract Pb	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Clays	2	2	44	40	48	1.4%	1.4%	2.92%	2.92%	3.1	0.076	0.6%	0.6%	<5	26.9%	24.8%	9.8%	9.3%
Anglesite	5	5	5	4	10	3.4%	3.4%	0.86%	0.86%	6.3	0.684	3.2%	3.2%	5-9	17.9%	17.9%	16.5%	16.5%
Barite	1	1	10	10	10	0.7%	0.7%	0.33%	0.33%	4.5	0.081	0.1%	0.1%	10-19	21.4%	21.4%	23.4%	23.4%
Cerussite	61	59	8	1	38	42.1%	40.7%	16.89%	16.82%	6.6	0.776	74.4%	74.1%	20-49	24.1%	23.4%	41.0%	37.3%
Fe Oxide	41	41	31	4	205	28.3%	28.3%	42.60%	42.60%	4	0.047	6.9%	6.9%	50-99	7.6%	7.6%	7.0%	7.0%
Galena	2	0	11	1	20	1.4%	0.0%	0.70%	0.00%	7.5	0.866	3.9%	0.0%	100-149	1.4%	1.4%	1.2%	1.2%
Mn Oxide	9	9	36	11	80	6.2%	6.2%	10.78%	10.78%	5	0.193	9.0%	9.0%	150-199	0.0%	0.0%	0.0%	0.0%
Phosphate	6	6	40	6	105	4.1%	4.1%	7.93%	7.93%	5	0.037	1.3%	1.3%	200-249	0.7%	0.7%	1.1%	1.1%
Pyrite	4	4	13	6	20	2.8%	2.8%	1.66%	1.66%	4.8	0.00007	0.0%	0.0%	≥250	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	14	14	33	1	96	9.7%	9.7%	15.33%	15.33%	3.7	0.0146	0.7%	0.7%					
															100%	97%	100%	96%

MINERAL FREQUENCY OBSERVED IN SITE SOIL
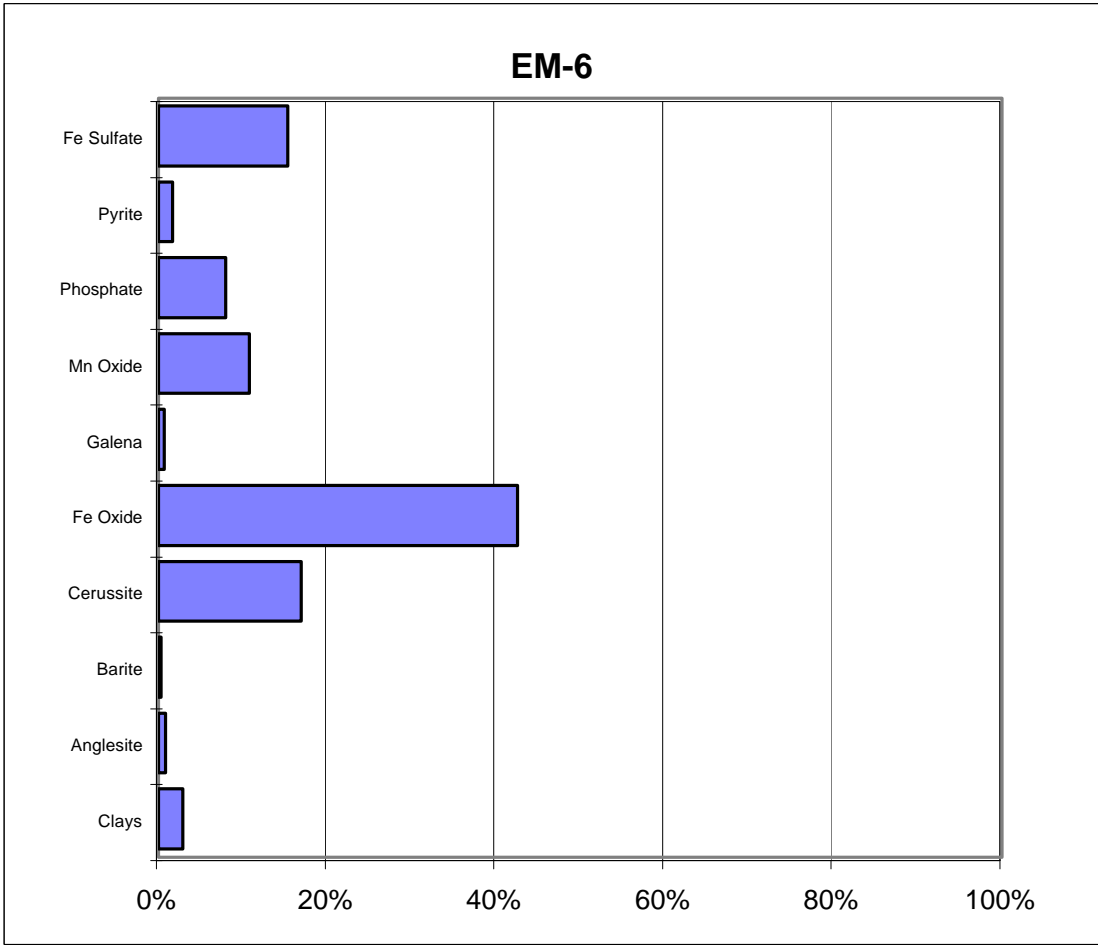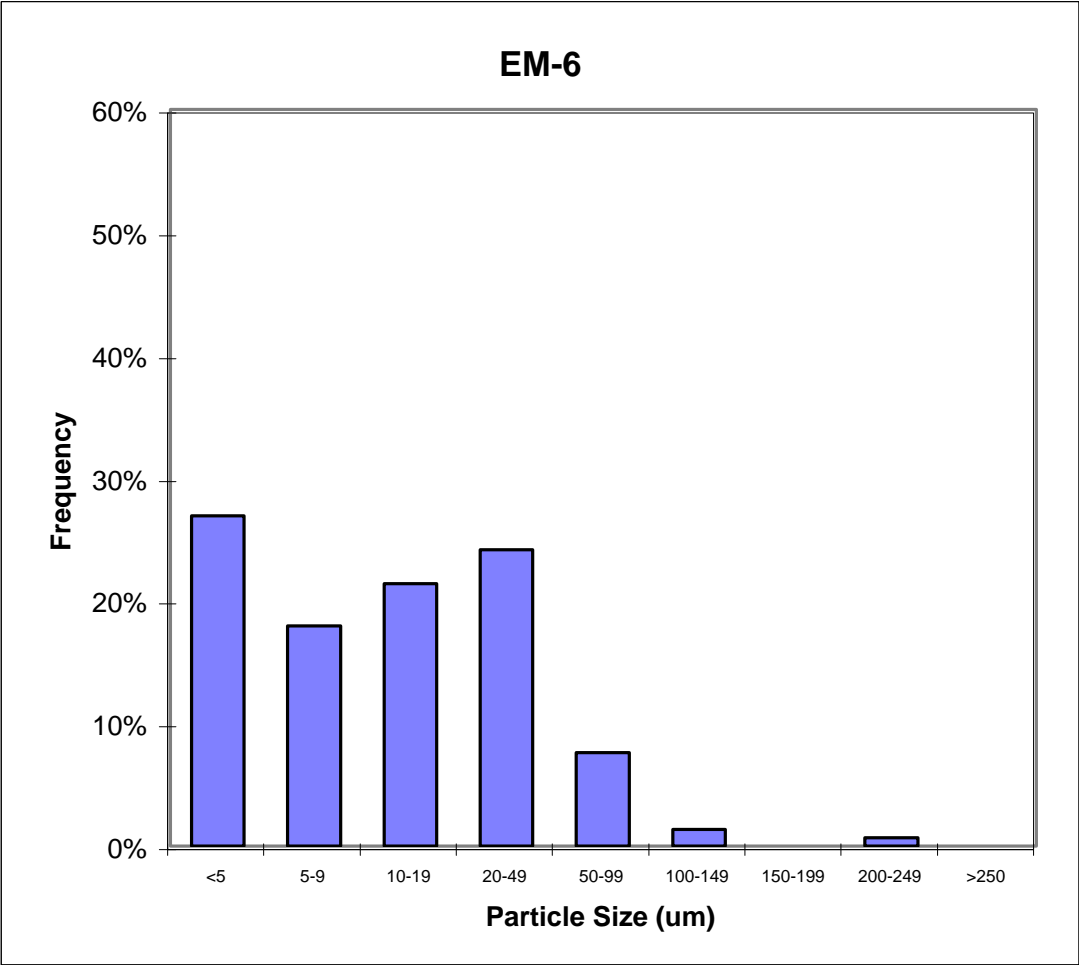
EM-6

FIGURE 1 PARTICLE SIZE DISTRIBUTION

EM-6

RELATIVE ARSENIC MASS

EM-6
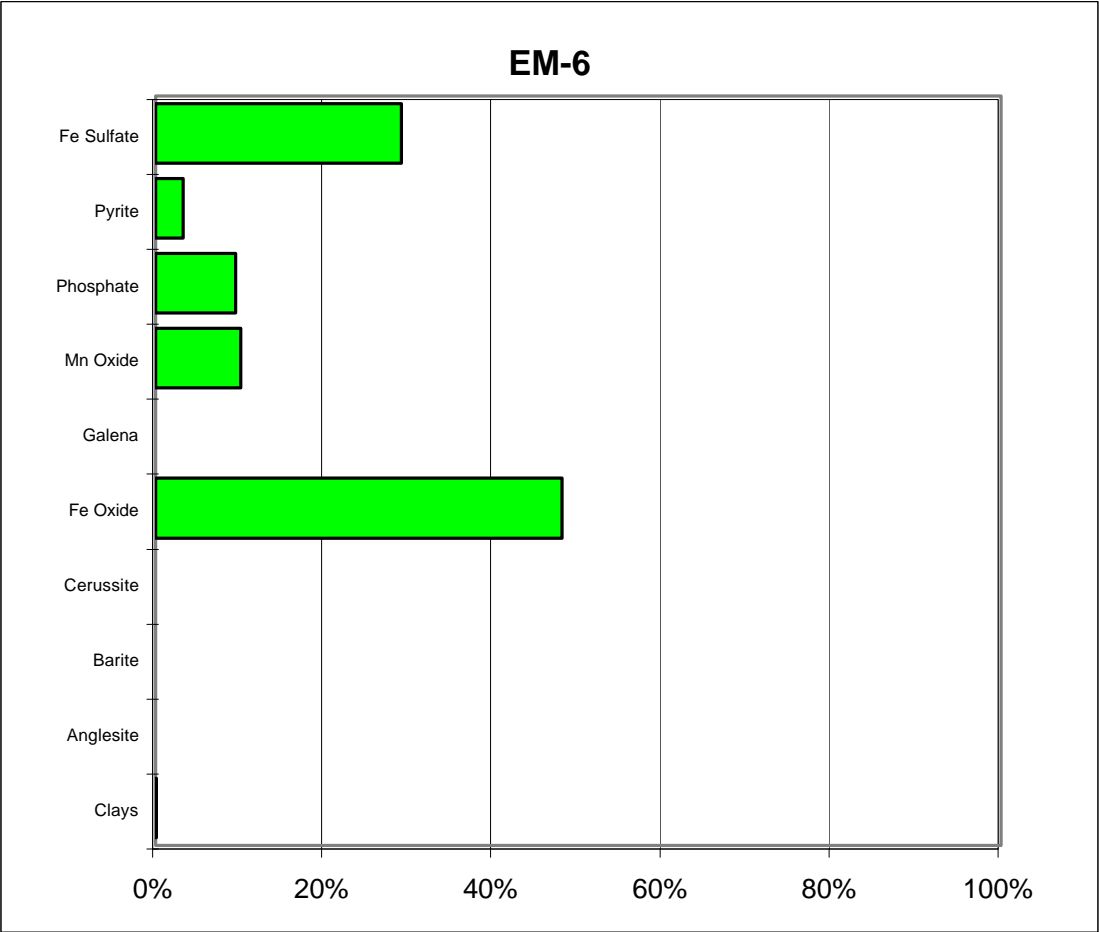
RELATIVE LEAD MASS
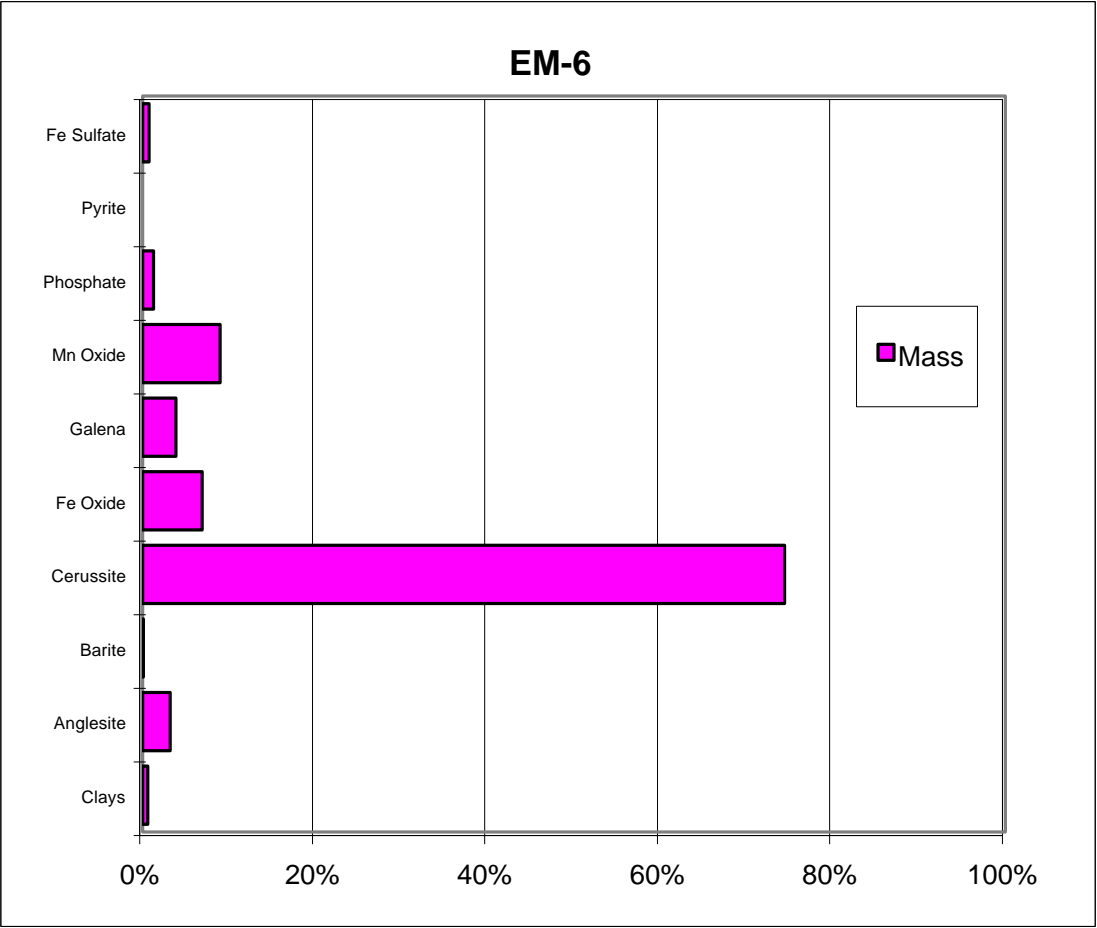
Summary

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Clays	2.9%	0.06%	2.9%	0.6%
Anglesite	0.9%	0.00%	0.9%	3.2%
Barite	0.3%	0.00%	0.3%	0.1%
Cerussite	16.9%	0.00%	16.9%	74.4%
Fe Oxide	42.6%	48.05%	42.6%	6.9%
Galena	0.7%	0.00%	0.7%	3.9%
Mn Oxide	10.8%	10.09%	10.8%	9.0%
Phosphate	7.9%	9.45%	7.9%	1.3%
Pyrite	1.7%	3.27%	1.7%	0.0%
Fe Sulfate	15.3%	29.08%	15.3%	0.7%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	26.9%	26.9%
5-9	17.9%	17.9%
10-19	21.4%	21.4%
20-49	24.1%	24.1%
50-99	7.6%	7.6%
100-149	1.4%	1.4%
150-199	0.0%	0.0%
200-249	0.7%	0.7%
≥250	0.0%	0.0%

SAMPLE ID EM-07

SUMMARY STATISTICS
EM-7 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract As	Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated			Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Calcite	1	1	4	4	4	0.5%	0.5%	0.19%	0.19%	2.7	0.0056	0.0%	0.0%	<5	65.3%	64.9%	8.1%	6.7%
Cerussite	39	38	20	1	105	19.3%	18.8%	37.33%	34.71%	6.6	0	0.0%	0.0%	5-9	15.3%	15.3%	9.1%	9.1%
Fe Oxide	123	123	8	1	145	60.9%	60.9%	46.46%	46.46%	4	0.011	25.4%	25.4%	10-19	6.9%	6.9%	3.5%	3.5%
Mn Oxide	1	1	21	21	21	0.5%	0.5%	1.00%	1.00%	5	0.0073	0.5%	0.5%	20-49	5.4%	5.4%	7.7%	7.7%
PbAsO	3	2	30	2	80	1.5%	1.0%	4.28%	4.18%	7.1	0.17	64.2%	62.8%	50-99	5.4%	5.0%	65.2%	65.2%
Phosphate	1	1	1	1	1	0.5%	0.5%	0.05%	0.05%	5	0.0093	0.0%	0.0%	100-149	1.5%	1.5%	6.4%	6.4%
Fe Sulfate	34	34	7	2	42	16.8%	16.8%	10.70%	10.70%	3.7	0.02	9.8%	9.8%	150-199	0.0%	0.0%	0.0%	0.0%
														200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	99%	100%	99%
TOTAL	202	200	10			100.0%	99.0%	100.00%	97.29%			100.0%	98.6%					

SUMMARY STATISTICS
EM-7 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract Pb	Relative Lead Mass (%)			DISTRIBUTION			
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated			Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Calcite	1	1	4	4	4	0.5%	0.5%	0.19%	0.19%	2.7	0.076	0.0%	0.0%	<5	65.3%	64.9%	5.2%	5.0%
Cerussite	39	38	20	1	105	19.3%	18.8%	37.33%	34.71%	6.6	0.776	86.6%	80.5%	5-9	15.3%	15.3%	8.3%	8.3%
Fe Oxide	123	123	8	1	145	60.9%	60.9%	46.46%	46.46%	4	0.047	4.0%	4.0%	10-19	6.9%	6.9%	6.9%	6.9%
Mn Oxide	1	1	21	21	21	0.5%	0.5%	1.00%	1.00%	5	0.193	0.4%	0.4%	20-49	5.4%	5.4%	15.8%	15.8%
PbAsO	3	2	30	2	80	1.5%	1.0%	4.28%	4.18%	7.1	0.633	8.7%	8.5%	50-99	5.4%	5.0%	51.3%	45.2%
Phosphate	1	1	1	1	1	0.5%	0.5%	0.05%	0.05%	5	0.037	0.0%	0.0%	100-149	1.5%	1.5%	12.6%	12.6%
Fe Sulfate	34	34	7	2	42	16.8%	16.8%	10.70%	10.70%	3.7	0.0146	0.3%	0.3%	150-199	0.0%	0.0%	0.0%	0.0%
														200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	99%	100%	94%

MINERAL FREQUENCY OBSERVED IN SITE SOIL
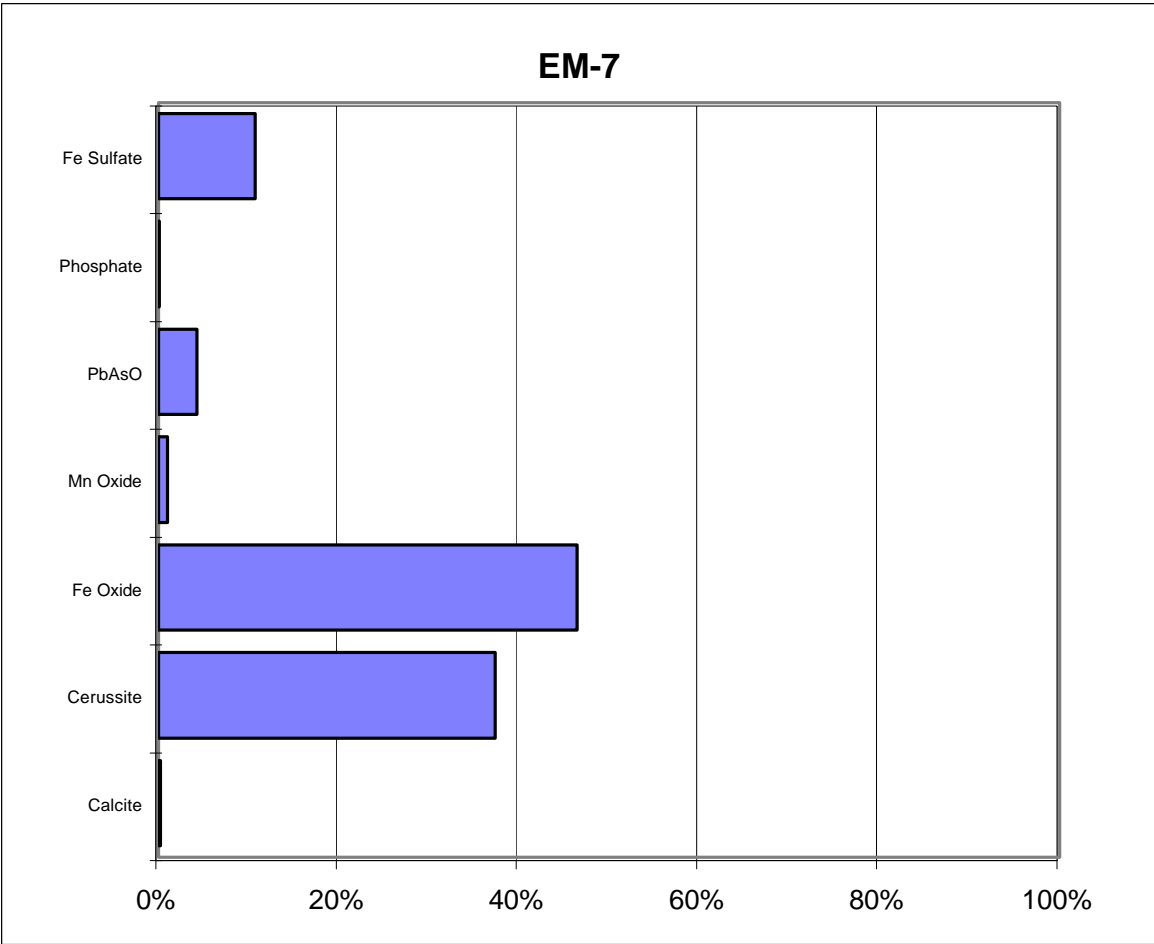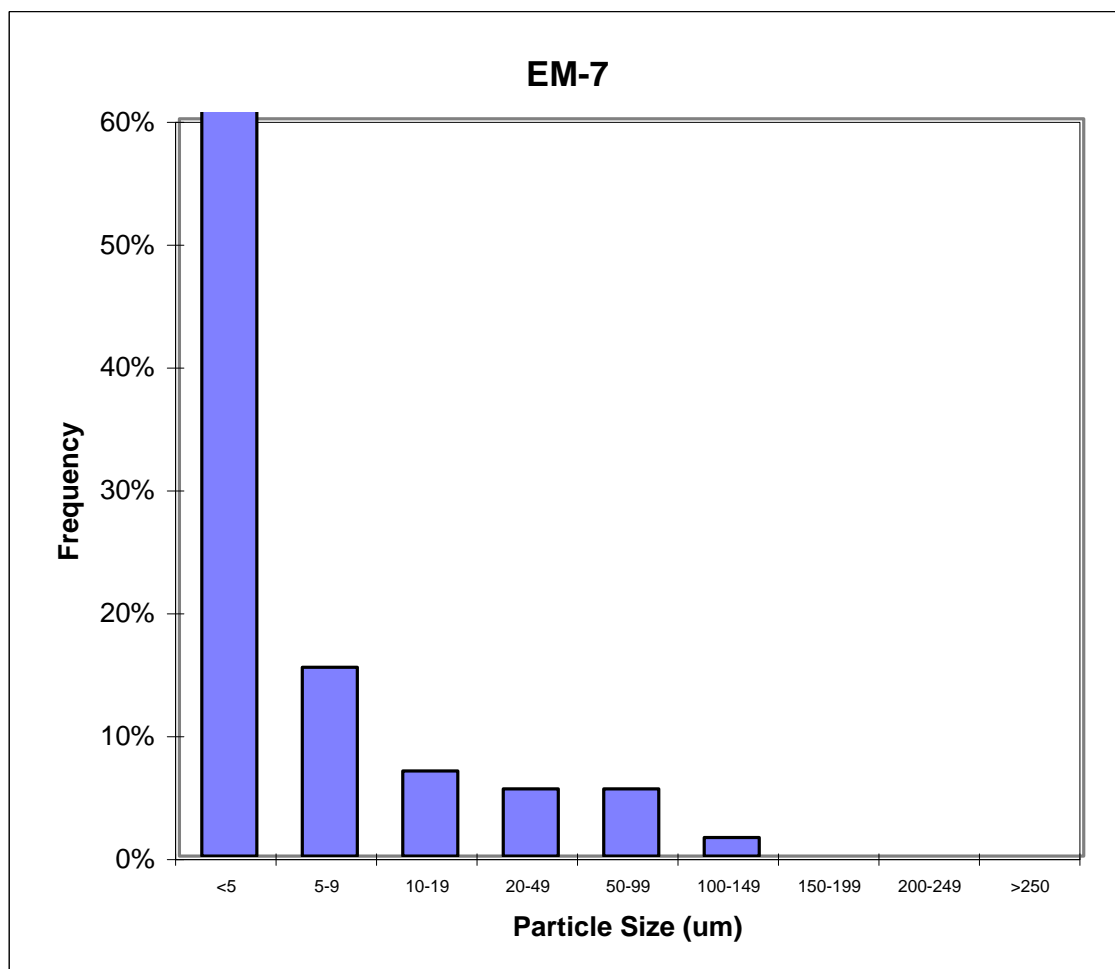
FIGURE 1 PARTICLE SIZE DISTRIBUTION

EM-7

RELATIVE ARSENIC MASS

RELATIVE LEAD MASS

EM-7

Fe Sulfate
Phosphate
PbAsO
Mn Oxide
Fe Oxide
Cerussite
Calcite

Mass

0%   20%   40%   60%   80%   100%
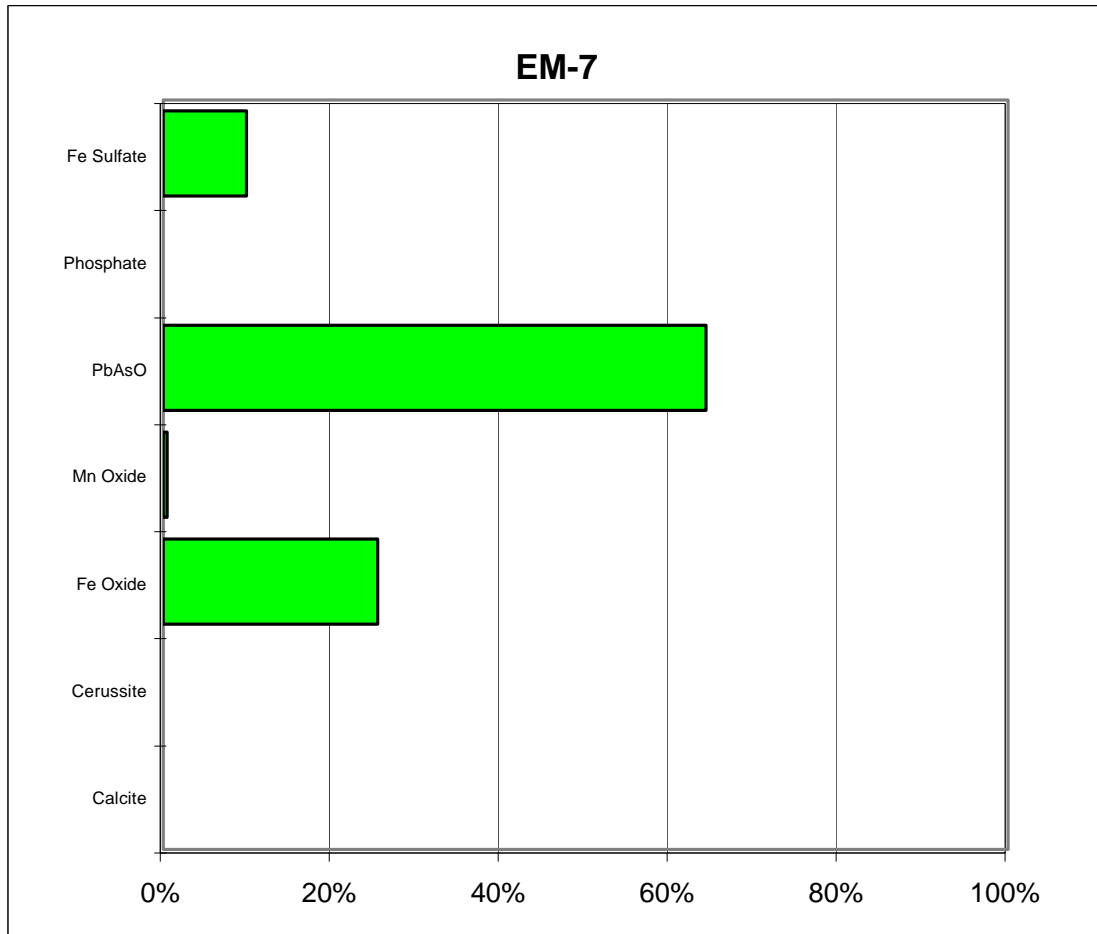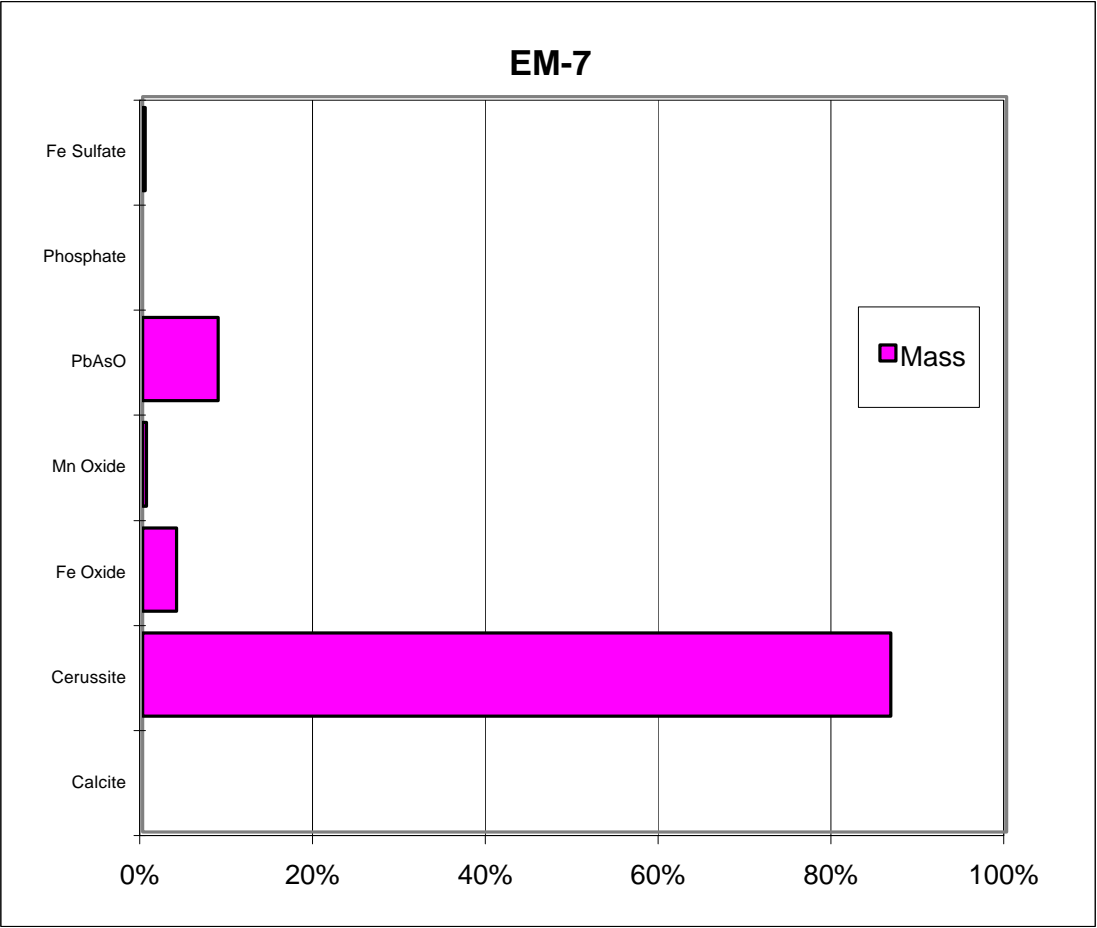
Summary

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Calcite	0.2%	0.04%	0.2%	0.0%
Cerussite	37.3%	0.00%	37.3%	86.6%
Fe Oxide	46.5%	25.42%	46.5%	4.0%
Mn Oxide	1.0%	0.45%	1.0%	0.4%
PbAsO	4.3%	64.22%	4.3%	8.7%
Phosphate	0.0%	0.03%	0.0%	0.0%
Fe Sulfate	10.7%	9.84%	10.7%	0.3%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	65.3%	65.3%
5-9	15.3%	15.3%
10-19	6.9%	6.9%
20-49	5.4%	5.4%
50-99	5.4%	5.4%
100-149	1.5%	1.5%
150-199	0.0%	0.0%
200-249	0.0%	0.0%
$\geq$250	0.0%	0.0%

SAMPLE ID EM-08

SUMMARY STATISTICS
EM-8 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract As	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Clays	1	1	22	22	22	0.8%	0.8%	1.32%	1.32%	3.1	0.00028	0.0%	0.0%	<5	40.2%	29.9%	7.8%	5.9%
Cerussite	19	19	13	1	100	15.0%	15.0%	14.41%	14.41%	6.6	0	0.0%	0.0%	5-9	22.8%	22.8%	7.9%	7.9%
Fe Oxide	34	34	23	2	140	26.8%	26.8%	46.91%	46.91%	4	0.011	34.1%	34.1%	10-19	17.3%	16.5%	14.0%	13.5%
Mn Oxide	12	6	8	1	48	9.4%	4.7%	5.71%	4.50%	5	0.0073	3.4%	2.7%	20-49	15.0%	15.0%	52.5%	52.5%
PbAsO	1	1	22	22	22	0.8%	0.8%	1.32%	1.32%	7.1	0.17	26.3%	26.3%	50-99	3.1%	3.1%	11.6%	11.6%
PbMO	1	1	23	23	23	0.8%	0.8%	1.38%	1.38%	7	0.038	6.1%	6.1%	100-149	1.6%	1.6%	6.1%	6.1%
Phosphate	19	19	10	3	22	15.0%	15.0%	11.53%	11.53%	5	0.0093	8.8%	8.8%	150-199	0.0%	0.0%	0.0%	0.0%
Pyrite	1	1	4	4	4	0.8%	0.8%	0.24%	0.24%	4.8	0.016	0.3%	0.3%	200-249	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	39	31	7	1	35	30.7%	24.4%	17.18%	15.80%	3.7	0.02	21.0%	19.3%	≥250	0.0%	0.0%	0.0%	0.0%
															100%	89%	100%	98%
TOTAL	127	113	13			100.0%	89.0%	100.00%	97.42%			100.0%	97.6%					

SUMMARY STATISTICS
EM-8 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract Pb	Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated			Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Clays	1	1	22	22	22	0.8%	0.8%	1.32%	1.32%	3.1	0.076	0.3%	0.3%	<5	40.2%	29.9%	7.2%	6.9%
Cerussite	19	19	13	1	100	15.0%	15.0%	14.41%	14.41%	6.6	0.776	72.5%	72.5%	5-9	22.8%	22.8%	16.9%	16.9%
Fe Oxide	34	34	23	2	140	26.8%	26.8%	46.91%	46.91%	4	0.047	8.7%	8.7%	10-19	17.3%	16.5%	7.0%	6.2%
Mn Oxide	12	6	8	1	48	9.4%	4.7%	5.71%	4.50%	5	0.193	5.4%	4.3%	20-49	15.0%	15.0%	34.1%	34.1%
PbAsO	1	1	22	22	22	0.8%	0.8%	1.32%	1.32%	7.1	0.633	5.8%	5.8%	50-99	3.1%	3.1%	3.0%	3.0%
PbMO	1	1	23	23	23	0.8%	0.8%	1.38%	1.38%	7	0.455	4.3%	4.3%	100-149	1.6%	1.6%	31.8%	31.8%
Phosphate	19	19	10	3	22	15.0%	15.0%	11.53%	11.53%	5	0.037	2.1%	2.1%	150-199	0.0%	0.0%	0.0%	0.0%
Pyrite	1	1	4	4	4	0.8%	0.8%	0.24%	0.24%	4.8	0.00007	0.0%	0.0%	200-249	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	39	31	7	1	35	30.7%	24.4%	17.18%	15.80%	3.7	0.0146	0.9%	0.8%	≥250	0.0%	0.0%	0.0%	0.0%
															100%	89%	100%	99%

MINERAL FREQUENCY OBSERVED IN SITE SOIL
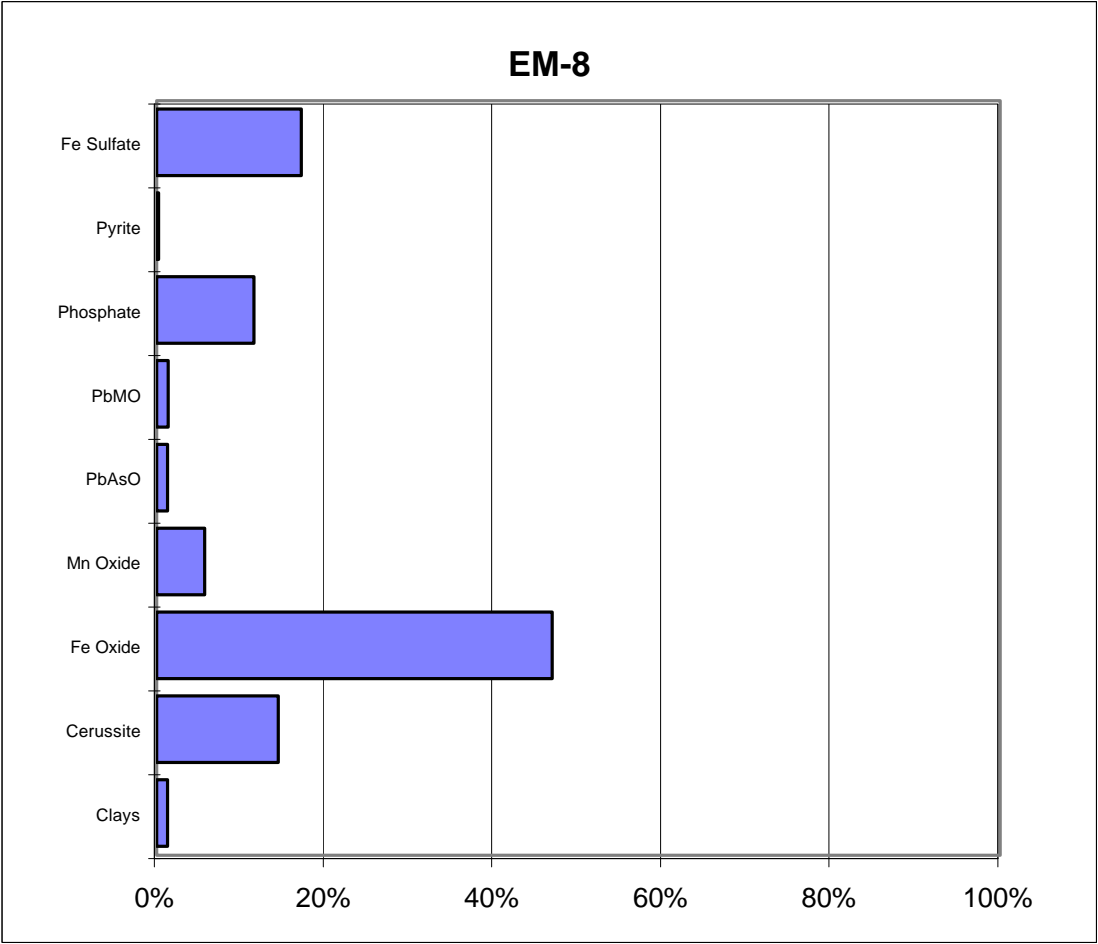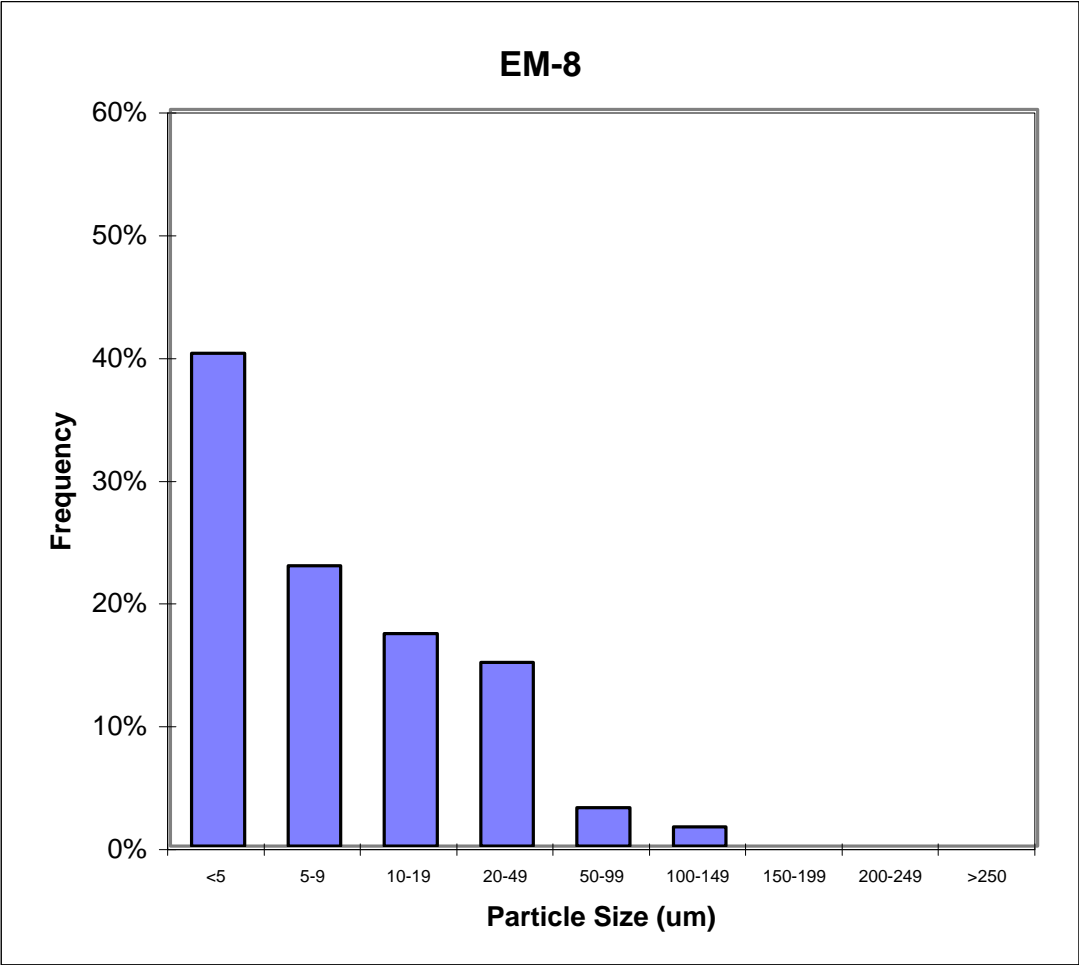
EM-8

FIGURE 1 PARTICLE SIZE DISTRIBUTION

RELATIVE ARSENIC MASS
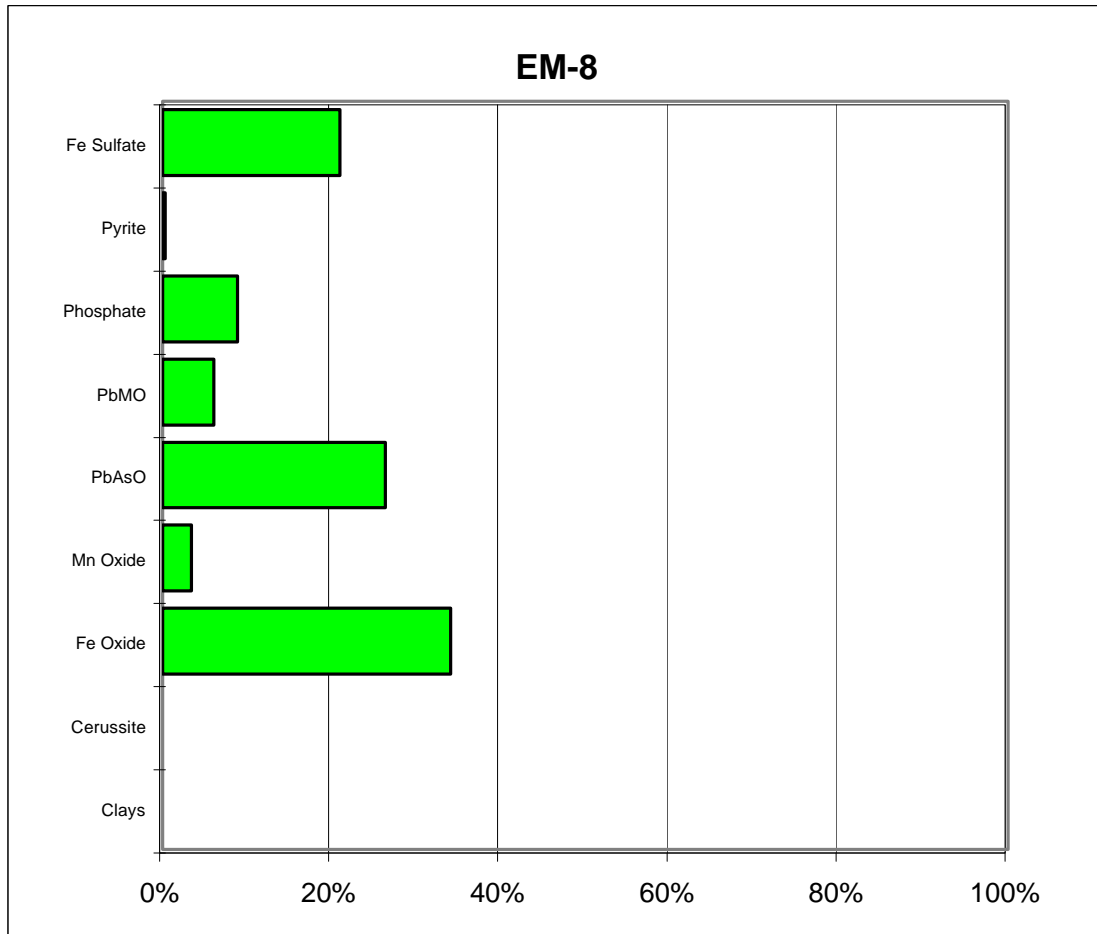
RELATIVE LEAD MASS
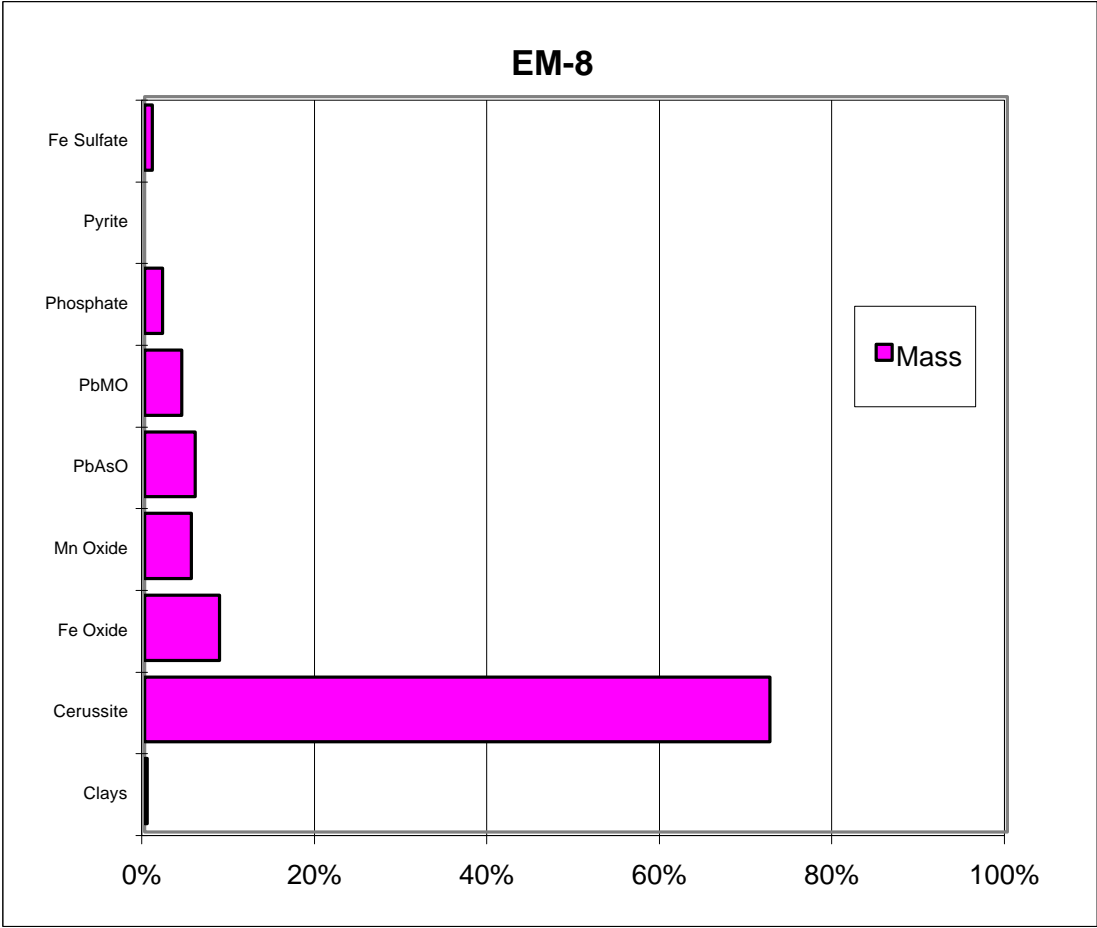
Summary

Mineral	Arsenic		Lead			Size	Arsenic	Lead
	Freq	Mass	Freq	Mass				
Clays	1.3%	0.02%	1.3%	0.3%		<5	40.2%	40.2%
Cerussite	14.4%	0.00%	14.4%	72.5%		5-9	22.8%	22.8%
Fe Oxide	46.9%	34.05%	46.9%	8.7%		10-19	17.3%	17.3%
Mn Oxide	5.7%	3.44%	5.7%	5.4%		20-49	15.0%	15.0%
PbAsO	1.3%	26.31%	1.3%	5.8%		50-99	3.1%	3.1%
PbMO	1.4%	6.06%	1.4%	4.3%		100-149	1.6%	1.6%
Phosphate	11.5%	8.85%	11.5%	2.1%		150-199	0.0%	0.0%
Pyrite	0.2%	0.30%	0.2%	0.0%		200-249	0.0%	0.0%
Fe Sulfate	17.2%	20.97%	17.2%	0.9%		≥250	0.0%	0.0%

Total 100% 100% 100% 100%

SAMPLE ID EM-09

SUMMARY STATISTICS
EM-9 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Arsenic Mass (%)			DISTRIBUTION			
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract As	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	9	9	15	1	65	9.8%	9.8%	11.46%	11.46%	6.6	0	0.0%	0.0%	<5	25.0%	23.9%	8.1%	7.9%
Fe Oxide	41	40	16	2	85	44.6%	43.5%	58.42%	58.25%	4	0.011	55.0%	54.9%	5-9	33.7%	33.7%	17.3%	17.3%
Mn Oxide	4	4	15	3	33	4.3%	4.3%	5.12%	5.12%	5	0.0073	4.0%	4.0%	10-19	25.0%	25.0%	26.8%	26.8%
PbAsO	1	1	1	1	1	1.1%	1.1%	0.09%	0.09%	7.1	0.17	2.2%	2.2%	20-49	13.0%	13.0%	34.3%	34.3%
PbMO	1	1	2	2	2	1.1%	1.1%	0.17%	0.17%	7	0.038	1.0%	1.0%	50-99	3.3%	3.3%	13.5%	13.5%
Phosphate	6	6	5	2	8	6.5%	6.5%	2.43%	2.43%	5	0.0093	2.4%	2.4%	100-149	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	30	30	9	2	34	32.6%	32.6%	22.31%	22.31%	3.7	0.02	35.3%	35.3%	150-199	0.0%	0.0%	0.0%	0.0%
														200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	99%	100%	100%
TOTAL	92	91	13			100.0%	98.9%	100.00%	99.83%			100.0%	99.8%					

SUMMARY STATISTICS
EM-9 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract Pb	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	9	9	15	1	65	9.8%	9.8%	11.46%	11.46%	6.6	0.776	76.0%	76.0%	<5	25.0%	23.9%	3.0%	3.0%
Fe Oxide	41	40	16	2	85	44.6%	43.5%	58.42%	58.25%	4	0.047	14.2%	14.2%	5-9	33.7%	33.7%	24.1%	24.1%
Mn Oxide	4	4	15	3	33	4.3%	4.3%	5.12%	5.12%	5	0.193	6.4%	6.4%	10-19	25.0%	25.0%	22.5%	22.5%
PbAsO	1	1	1	1	1	1.1%	1.1%	0.09%	0.09%	7.1	0.633	0.5%	0.5%	20-49	13.0%	13.0%	9.4%	9.4%
PbMO	1	1	2	2	2	1.1%	1.1%	0.17%	0.17%	7	0.455	0.7%	0.7%	50-99	3.3%	3.3%	40.9%	40.9%
Phosphate	6	6	5	2	8	6.5%	6.5%	2.43%	2.43%	5	0.037	0.6%	0.6%	100-149	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	30	30	9	2	34	32.6%	32.6%	22.31%	22.31%	3.7	0.0146	1.6%	1.6%	150-199	0.0%	0.0%	0.0%	0.0%
														200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	99%	100%	100%

MINERAL FREQUENCY OBSERVED IN SITE SOIL
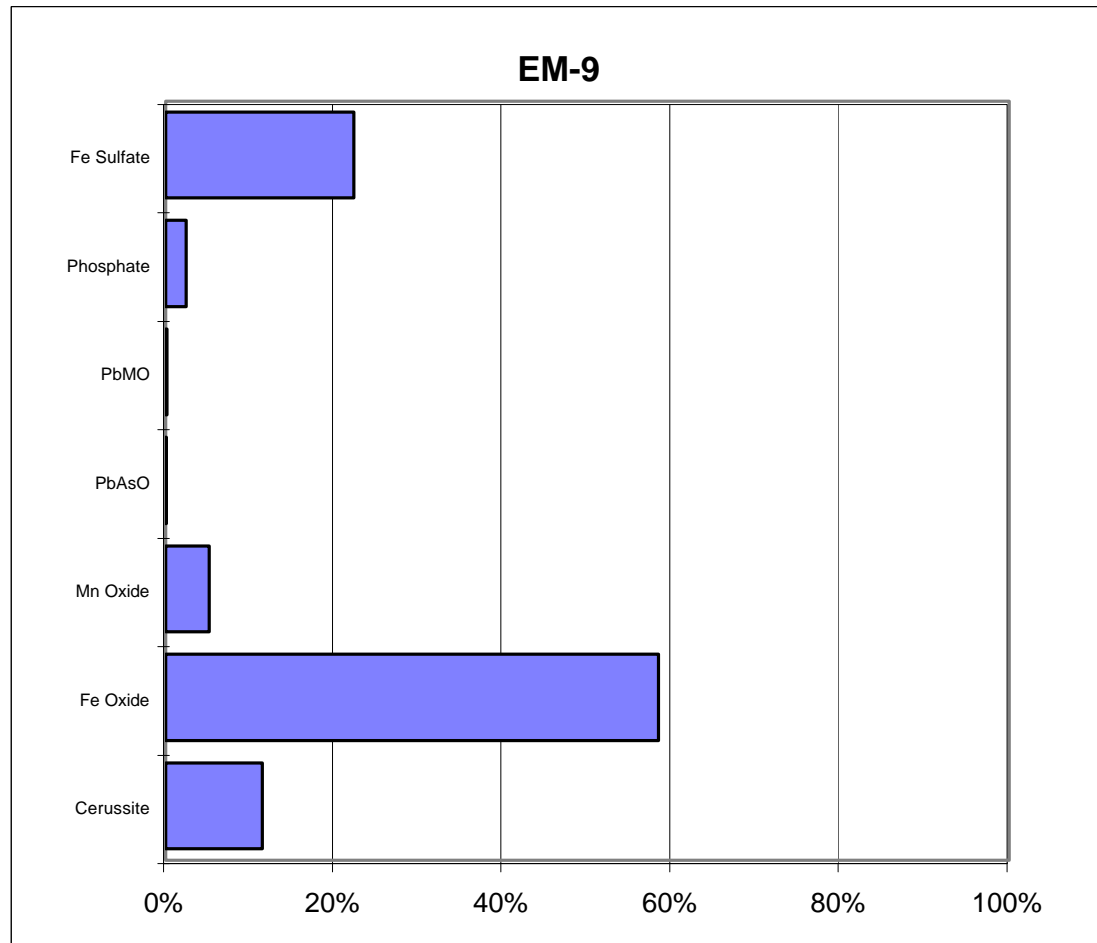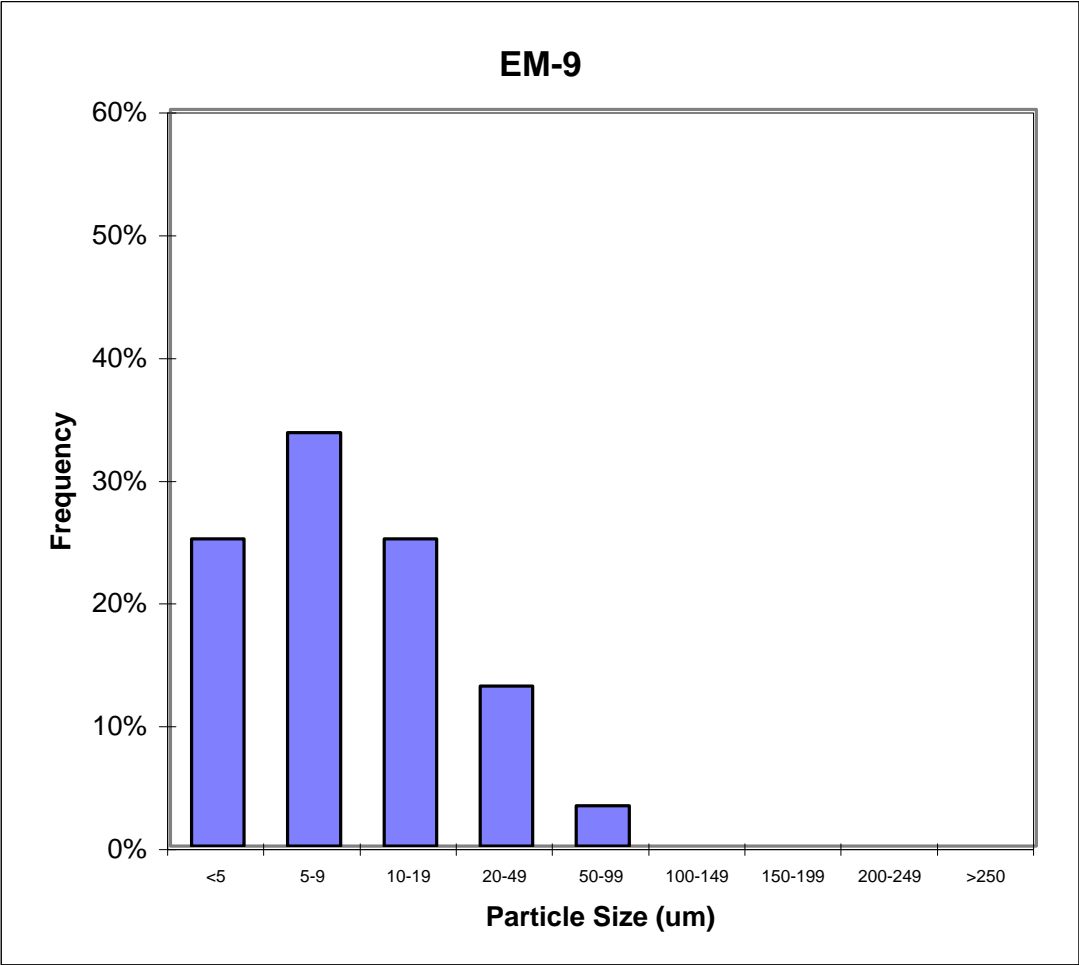
EM-9

FIGURE 1 PARTICLE SIZE DISTRIBUTION

EM-9

RELATIVE ARSENIC MASS

EM-9
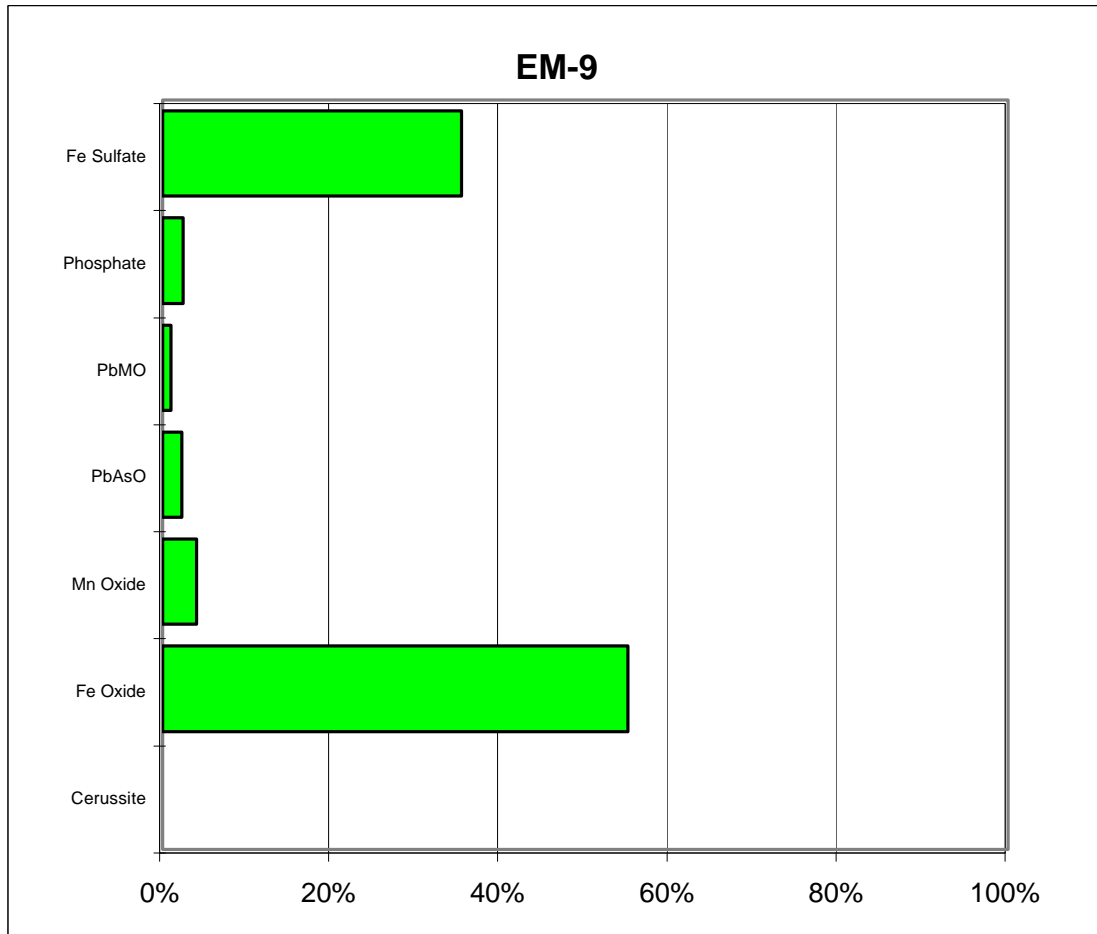
RELATIVE LEAD MASS
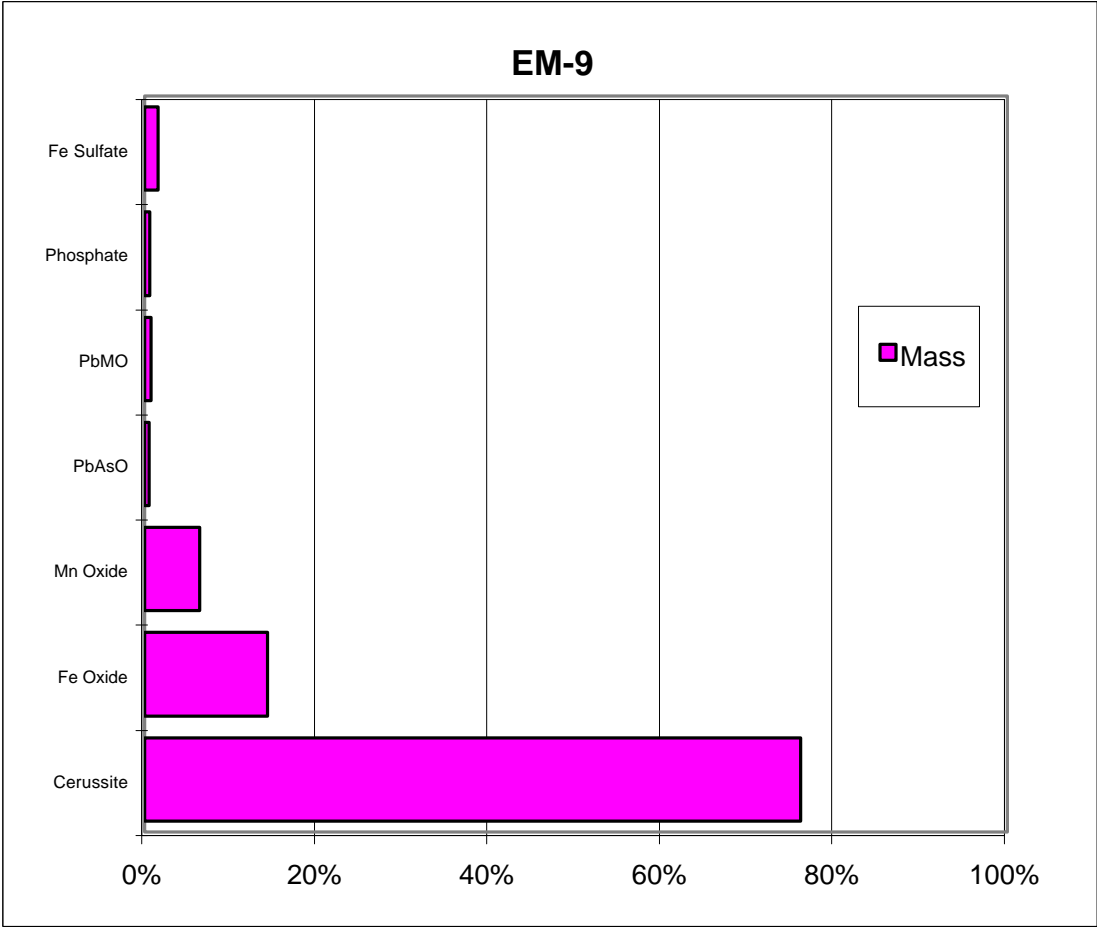
Summary

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Cerussite	11.5%	0.00%	11.5%	76.0%
Fe Oxide	58.4%	55.02%	58.4%	14.2%
Mn Oxide	5.1%	4.00%	5.1%	6.4%
PbAsO	0.1%	2.24%	0.1%	0.5%
PbMO	0.2%	0.99%	0.2%	0.7%
Phosphate	2.4%	2.42%	2.4%	0.6%
Fe Sulfate	22.3%	35.33%	22.3%	1.6%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	25.0%	25.0%
5-9	33.7%	33.7%
10-19	25.0%	25.0%
20-49	13.0%	13.0%
50-99	3.3%	3.3%
100-149	0.0%	0.0%
150-199	0.0%	0.0%
200-249	0.0%	0.0%
≥250	0.0%	0.0%

SAMPLE ID EM-10

SUMMARY STATISTICS
EM-10 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract As	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	5	5	5	1	20	3.4%	3.4%	2.11%	2.11%	6.6	0	0.0%	0.0%	<5	60.4%	52.3%	17.7%	14.9%
Fe Oxide	76	76	9	1	80	51.0%	51.0%	53.69%	53.69%	4	0.011	34.9%	34.9%	5-9	16.1%	14.8%	34.1%	32.8%
Mn Oxide	15	15	10	3	35	10.1%	10.1%	12.49%	12.49%	5	0.0073	6.7%	6.7%	10-19	14.8%	14.8%	20.3%	20.3%
PbAsO	3	3	7	4	8	2.0%	2.0%	1.62%	1.62%	7.1	0.17	28.9%	28.9%	20-49	6.0%	6.0%	12.1%	12.1%
PbMO	2	2	10	8	12	1.3%	1.3%	1.62%	1.62%	7	0.038	6.4%	6.4%	50-99	2.7%	2.7%	15.8%	15.8%
Phosphate	29	29	9	2	80	19.5%	19.5%	20.11%	20.11%	5	0.0093	13.8%	13.8%	100-149	0.0%	0.0%	0.0%	0.0%
Pyrite	1	1	12	12	12	0.7%	0.7%	0.97%	0.97%	4.8	0.016	1.1%	1.1%	150-199	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	18	4	5	2	14	12.1%	2.7%	7.38%	3.65%	3.7	0.02	8.1%	4.0%	200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	91%	100%	96%
TOTAL	149	135	8			100.0%	90.6%	100.00%	96.27%			100.0%	95.9%					

SUMMARY STATISTICS
EM-10 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract Pb	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	5	5	5	1	20	3.4%	3.4%	2.11%	2.11%	6.6	0.776	21.8%	21.8%	<5	60.4%	52.3%	15.2%	14.9%
Fe Oxide	76	76	9	1	80	51.0%	51.0%	53.69%	53.69%	4	0.047	20.4%	20.4%	5-9	16.1%	14.8%	24.8%	24.6%
Mn Oxide	15	15	10	3	35	10.1%	10.1%	12.49%	12.49%	5	0.193	24.3%	24.3%	10-19	14.8%	14.8%	22.7%	22.7%
PbAsO	3	3	7	4	8	2.0%	2.0%	1.62%	1.62%	7.1	0.633	14.7%	14.7%	20-49	6.0%	6.0%	28.3%	28.3%
PbMO	2	2	10	8	12	1.3%	1.3%	1.62%	1.62%	7	0.455	10.4%	10.4%	50-99	2.7%	2.7%	9.0%	9.0%
Phosphate	29	29	9	2	80	19.5%	19.5%	20.11%	20.11%	5	0.037	7.5%	7.5%	100-149	0.0%	0.0%	0.0%	0.0%
Pyrite	1	1	12	12	12	0.7%	0.7%	0.97%	0.97%	4.8	0.00007	0.0%	0.0%	150-199	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	18	4	5	2	14	12.1%	2.7%	7.38%	3.65%	3.7	0.0146	0.8%	0.4%	200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	91%	100%	100%

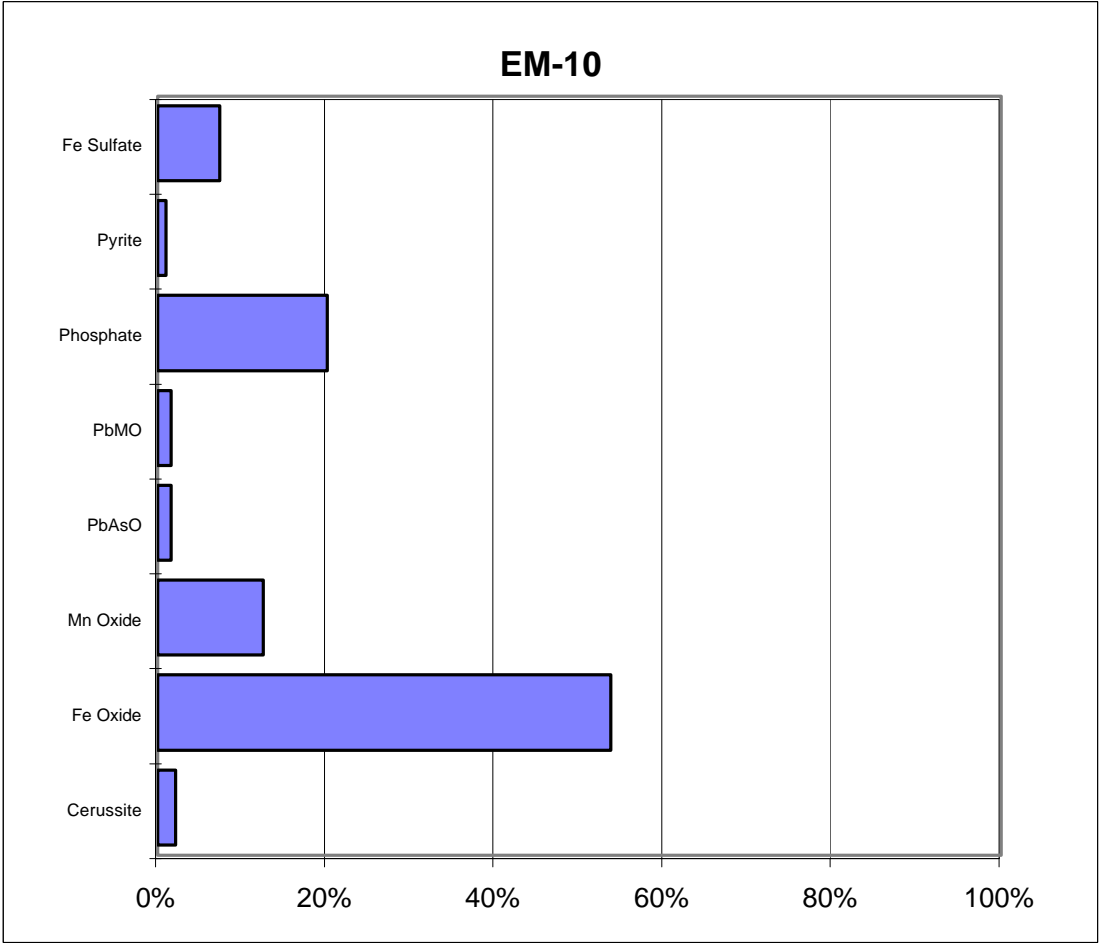# MINERAL FREQUENCY OBSERVED IN SITE SOIL
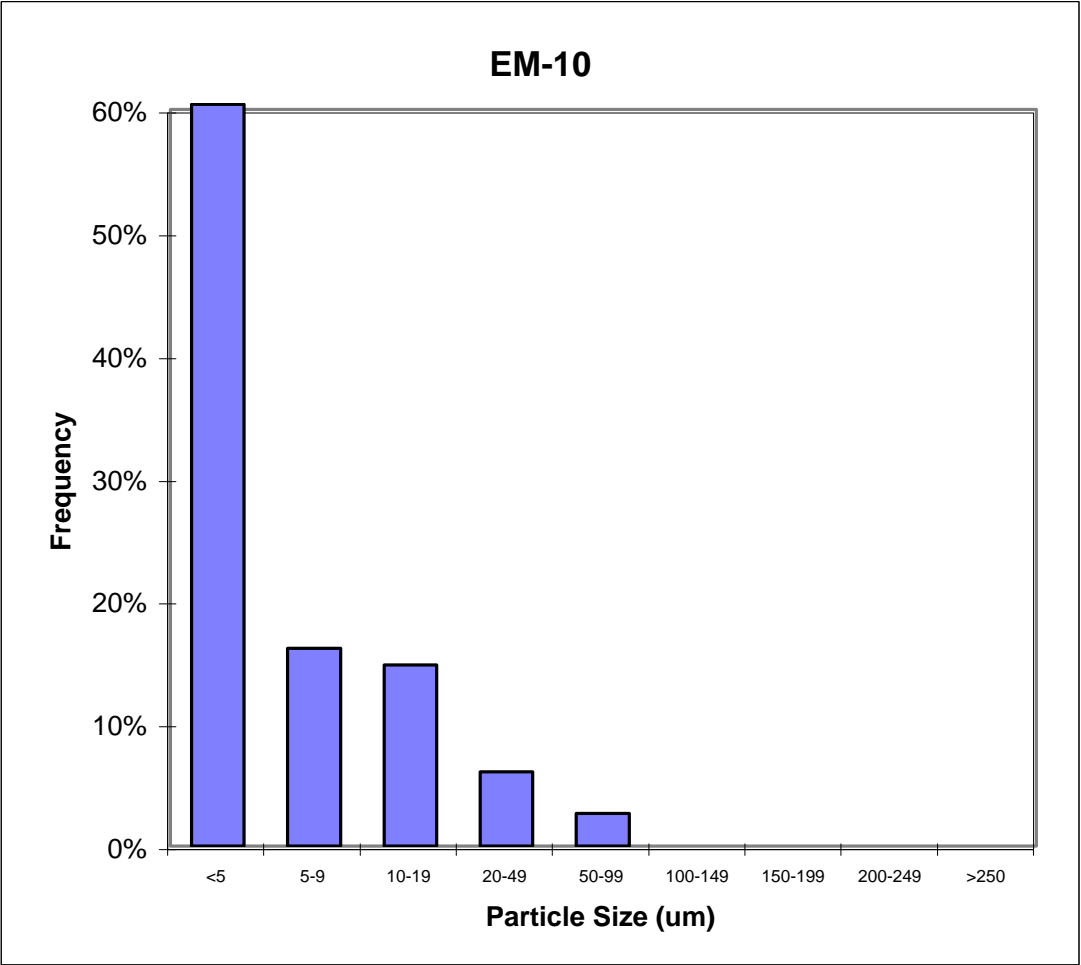
EM-10

FIGURE 1 PARTICLE SIZE DISTRIBUTION

EM-10

RELATIVE ARSENIC MASS
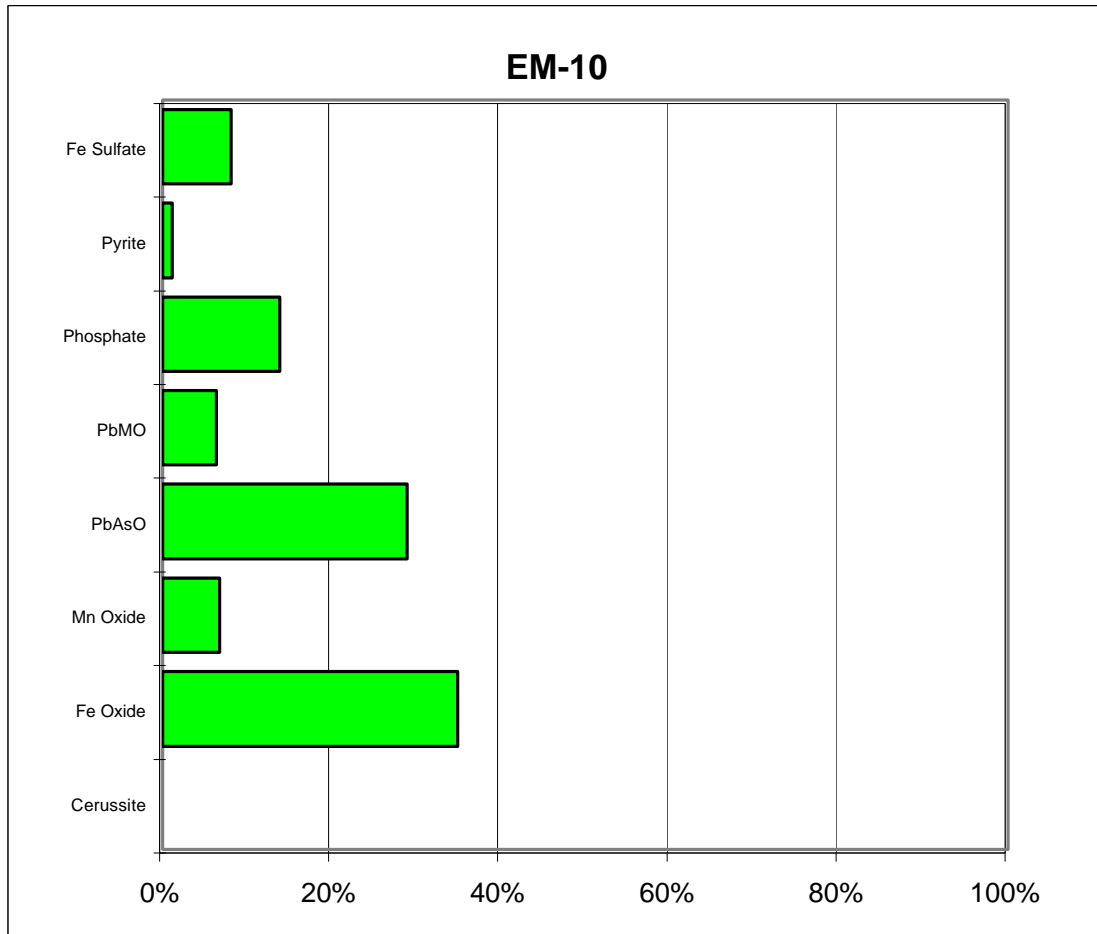
RELATIVE LEAD MASS
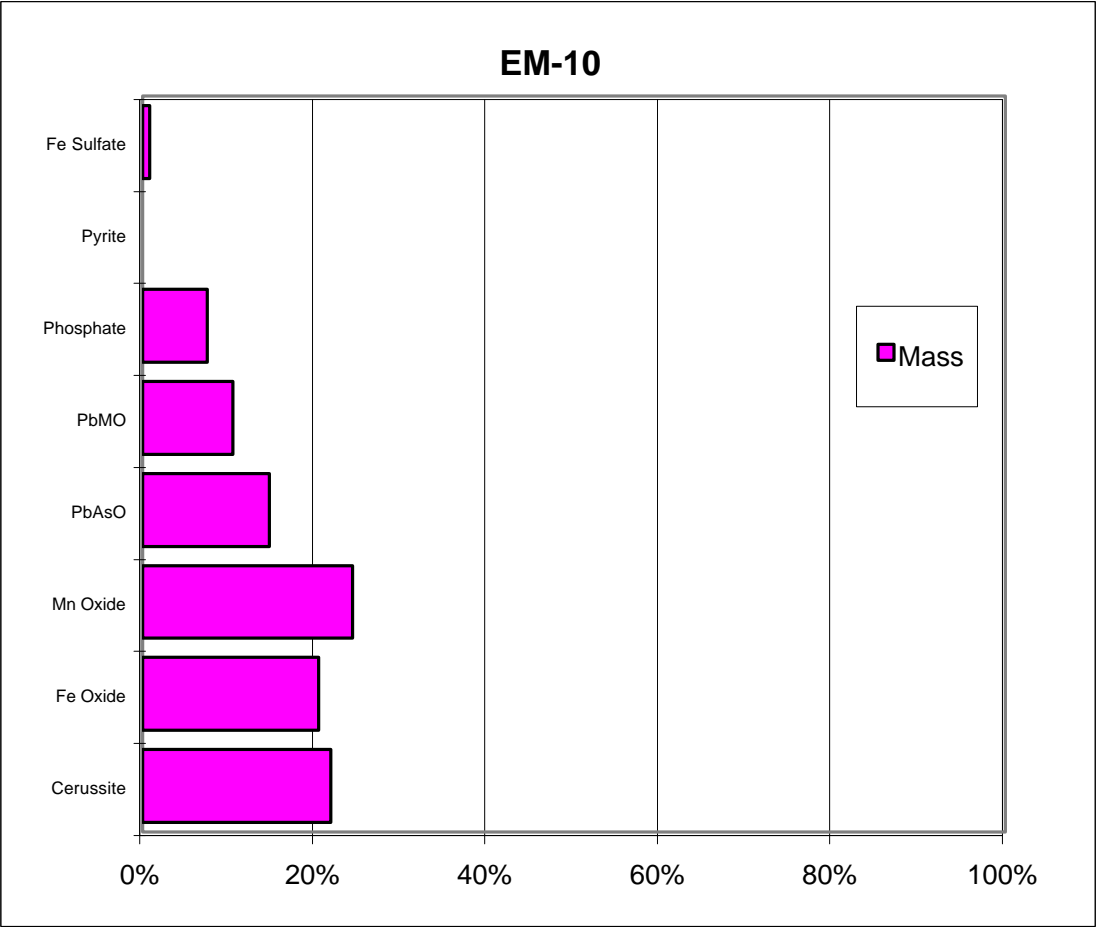
Summary

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Cerussite	2.1%	0.00%	2.1%	21.8%
Fe Oxide	53.7%	34.93%	53.7%	20.4%
Mn Oxide	12.5%	6.74%	12.5%	24.3%
PbAsO	1.6%	28.95%	1.6%	14.7%
PbMO	1.6%	6.38%	1.6%	10.4%
Phosphate	20.1%	13.83%	20.1%	7.5%
Pyrite	1.0%	1.11%	1.0%	0.0%
Fe Sulfate	7.4%	8.07%	7.4%	0.8%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	60.4%	60.4%
5-9	16.1%	16.1%
10-19	14.8%	14.8%
20-49	6.0%	6.0%
50-99	2.7%	2.7%
100-149	0.0%	0.0%
150-199	0.0%	0.0%
200-249	0.0%	0.0%
≥250	0.0%	0.0%

SAMPLE ID EM-11

SUMMARY STATISTICS
EM-11 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract As	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	40	40	18	1	100	15.4%	15.4%	10.81%	10.81%	6.6	0	0.0%	0.0%	<5	51.2%	51.2%	3.6%	3.6%
Fe Oxide	130	130	33	1	225	50.0%	50.0%	66.54%	66.54%	4	0.011	38.0%	38.0%	5-9	6.5%	6.5%	2.8%	2.8%
Mn Oxide	3	3	89	36	132	1.2%	1.2%	4.07%	4.07%	5	0.0073	1.9%	1.9%	10-19	11.2%	11.2%	9.2%	9.2%
PbAsO	5	5	37	8	112	1.9%	1.9%	2.85%	2.85%	7.1	0.17	44.6%	44.6%	20-49	13.1%	13.1%	17.9%	17.9%
PbMO	8	8	3	2	5	3.1%	3.1%	0.38%	0.38%	7	0.038	1.3%	1.3%	50-99	9.6%	9.6%	13.3%	13.3%
Phosphate	1	1	125	125	125	0.4%	0.4%	1.91%	1.91%	5	0.0093	1.2%	1.2%	100-149	6.9%	6.9%	45.9%	45.9%
Pyrite	2	2	21	9	32	0.8%	0.8%	0.63%	0.63%	4.8	0.016	0.6%	0.6%	150-199	1.2%	1.2%	5.4%	5.4%
Fe Sulfate	71	71	12	1	175	27.3%	27.3%	12.81%	12.81%	3.7	0.02	12.3%	12.3%	200-249	0.4%	0.4%	2.0%	2.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	100%	100%	100%
TOTAL	260	260	25			100.0%	100.0%	100.00%	100.00%			100.0%	100.0%					

SUMMARY STATISTICS
EM-11 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract Pb	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	40	40	18	1	100	15.4%	15.4%	10.81%	10.81%	6.6	0.776	63.7%	63.7%	<5	51.2%	51.2%	5.9%	5.9%
Fe Oxide	130	130	33	1	225	50.0%	50.0%	66.54%	66.54%	4	0.047	14.4%	14.4%	5-9	6.5%	6.5%	4.8%	4.8%
Mn Oxide	3	3	89	36	132	1.2%	1.2%	4.07%	4.07%	5	0.193	4.5%	4.5%	10-19	11.2%	11.2%	6.0%	6.0%
PbAsO	5	5	37	8	112	1.9%	1.9%	2.85%	2.85%	7.1	0.633	14.7%	14.7%	20-49	13.1%	13.1%	27.9%	27.9%
PbMO	8	8	3	2	5	3.1%	3.1%	0.38%	0.38%	7	0.455	1.4%	1.4%	50-99	9.6%	9.6%	34.6%	34.6%
Phosphate	1	1	125	125	125	0.4%	0.4%	1.91%	1.91%	5	0.037	0.4%	0.4%	100-149	6.9%	6.9%	18.7%	18.7%
Pyrite	2	2	21	9	32	0.8%	0.8%	0.63%	0.63%	4.8	0.00007	0.0%	0.0%	150-199	1.2%	1.2%	1.4%	1.4%
Fe Sulfate	71	71	12	1	175	27.3%	27.3%	12.81%	12.81%	3.7	0.0146	0.8%	0.8%	200-249	0.4%	0.4%	0.8%	0.8%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	100%	100%	100%

MINERAL FREQUENCY OBSERVED IN SITE SOIL
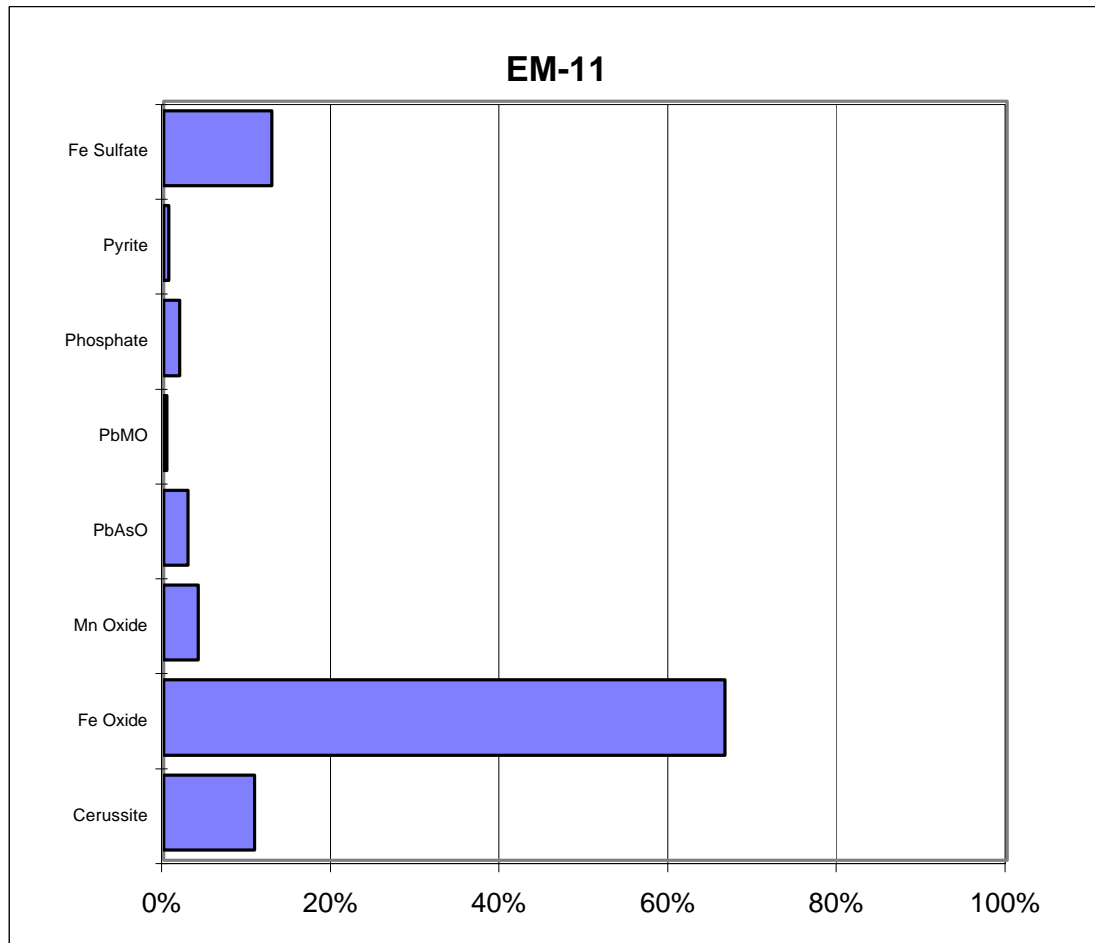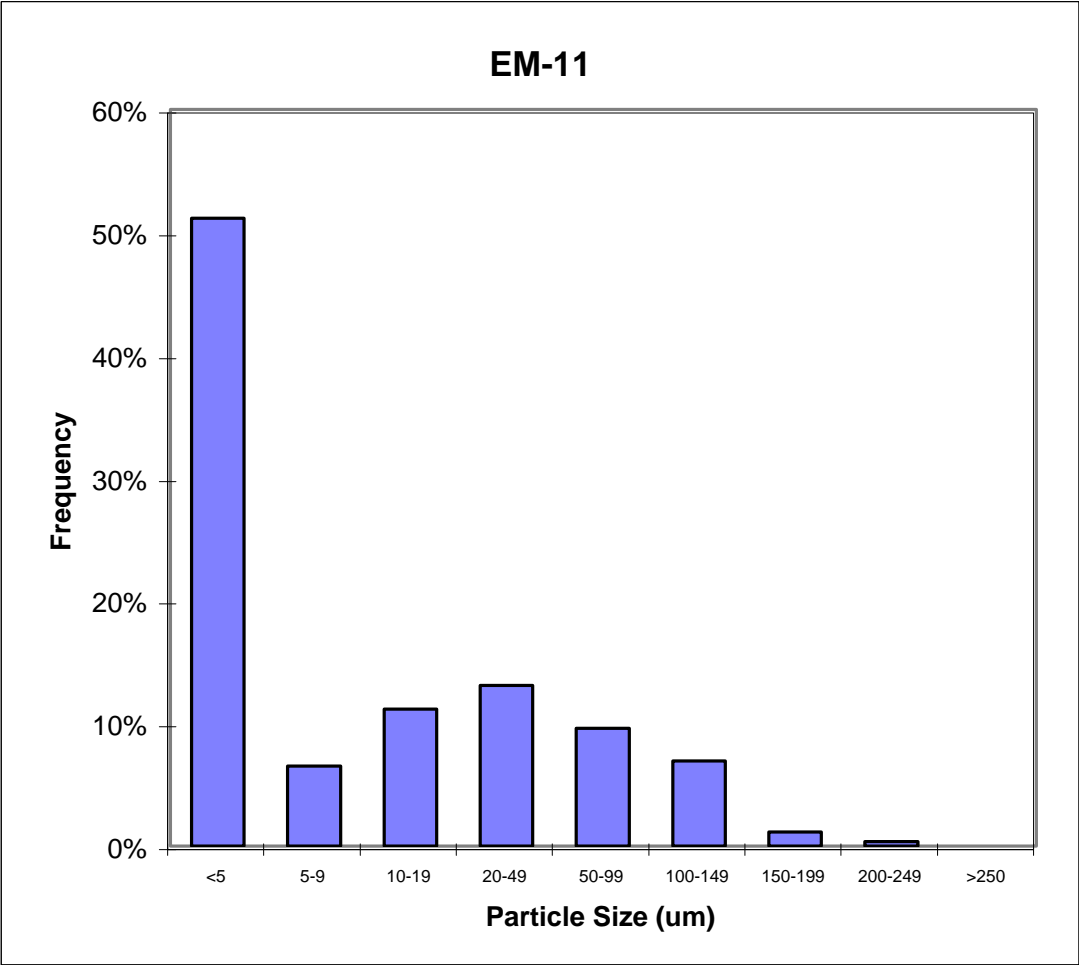

EM-11

FIGURE 1 PARTICLE SIZE DISTRIBUTION

EM-11

RELATIVE ARSENIC MASS

EM-11

RELATIVE LEAD MASS

EM-11

Fe Sulfate, Pyrite, Phosphate, PbMO, PbAsO, Mn Oxide, Fe Oxide, Cerussite
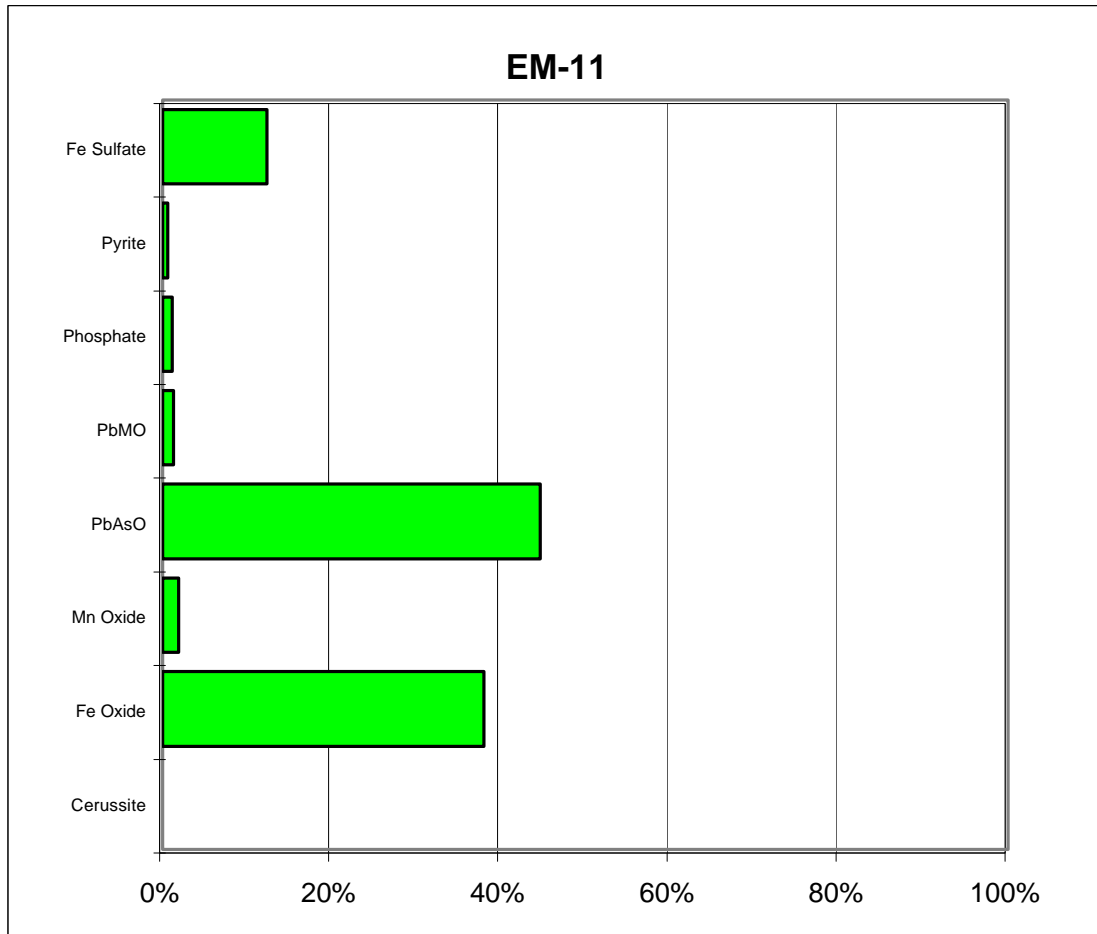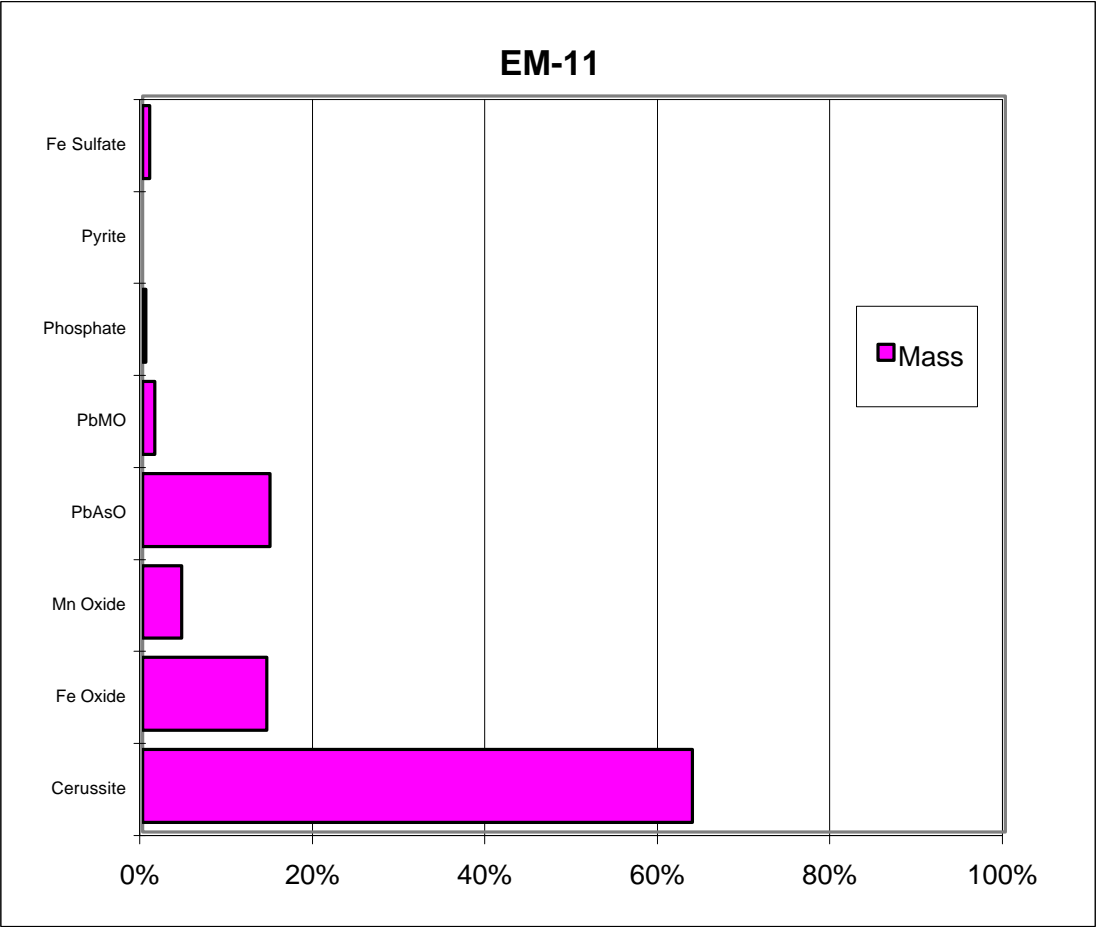
Mass

Summary

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Cerussite	10.8%	0.00%	10.8%	63.7%
Fe Oxide	66.5%	38.03%	66.5%	14.4%
Mn Oxide	4.1%	1.93%	4.1%	4.5%
PbAsO	2.8%	44.63%	2.8%	14.7%
PbMO	0.4%	1.32%	0.4%	1.4%
Phosphate	1.9%	1.16%	1.9%	0.4%
Pyrite	0.6%	0.63%	0.6%	0.0%
Fe Sulfate	12.8%	12.31%	12.8%	0.8%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	51.2%	51.2%
5-9	6.5%	6.5%
10-19	11.2%	11.2%
20-49	13.1%	13.1%
50-99	9.6%	9.6%
100-149	6.9%	6.9%
150-199	1.2%	1.2%
200-249	0.4%	0.4%
≥250	0.0%	0.0%

SAMPLE ID EM-12

SUMMARY STATISTICS
EM-12 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract As	Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract As	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
AsMO	1	1	8	8	8	0.5%	0.5%	0.19%	0.19%	7	0.1955	4.8%	4.8%	<5	36.4%	33.0%	5.0%	5.0%
Cerussite	33	26	27	2	110	16.0%	12.6%	20.78%	20.11%	6.6	0	0.0%	0.0%	5-9	18.0%	16.0%	19.5%	19.1%
Fe Oxide	62	62	25	3	122	30.1%	30.1%	36.65%	36.65%	4	0.011	30.7%	30.7%	10-19	13.6%	13.6%	6.3%	6.3%
Mn Oxide	42	42	23	3	105	20.4%	20.4%	22.55%	22.55%	5	0.0073	15.7%	15.7%	20-49	19.9%	19.9%	37.4%	37.4%
PbAsO	5	5	10	3	25	2.4%	2.4%	1.14%	1.14%	7.1	0.17	26.1%	26.1%	50-99	7.3%	7.3%	17.7%	17.7%
Phosphate	11	9	29	1	135	5.3%	4.4%	7.40%	7.35%	5	0.0093	6.6%	6.5%	100-149	4.9%	4.9%	14.1%	14.1%
Pyrite	23	22	3	2	20	11.2%	10.7%	1.83%	1.67%	4.8	0.016	2.7%	2.4%	150-199	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	29	28	14	1	106	14.1%	13.6%	9.46%	9.32%	3.7	0.02	13.3%	13.2%	200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	95%	100%	100%
TOTAL	206	195	21			100.0%	94.7%	100.00%	98.98%			100.0%	99.5%					

SUMMARY STATISTICS
EM-12 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract Pb	Relative Lead Mass (%)		Size	DISTRIBUTION			
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated			Total	Liberated		Total Freq	Lib Freq	Total RAM	Lib RAM
AsMO	1	1	8	8	8	0.5%	0.5%	0.19%	0.19%	7	0.3	0.3%	0.3%	<5	36.4%	33.0%	3.1%	1.8%
Cerussite	33	26	27	2	110	16.0%	12.6%	20.78%	20.11%	6.6	0.776	74.7%	72.3%	5-9	18.0%	16.0%	7.9%	6.8%
Fe Oxide	62	62	25	3	122	30.1%	30.1%	36.65%	36.65%	4	0.047	4.8%	4.8%	10-19	13.6%	13.6%	5.9%	5.9%
Mn Oxide	42	42	23	3	105	20.4%	20.4%	22.55%	22.55%	5	0.193	15.3%	15.3%	20-49	19.9%	19.9%	18.3%	18.3%
PbAsO	5	5	10	3	25	2.4%	2.4%	1.14%	1.14%	7.1	0.633	3.6%	3.6%	50-99	7.3%	7.3%	25.6%	25.6%
Phosphate	11	9	29	1	135	5.3%	4.4%	7.40%	7.35%	5	0.037	1.0%	1.0%	100-149	4.9%	4.9%	39.2%	39.2%
Pyrite	23	22	3	2	20	11.2%	10.7%	1.83%	1.67%	4.8	0.00007	0.0%	0.0%	150-199	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	29	28	14	1	106	14.1%	13.6%	9.46%	9.32%	3.7	0.0146	0.4%	0.4%	200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	95%	100%	98%

MINERAL FREQUENCY OBSERVED IN SITE SOIL
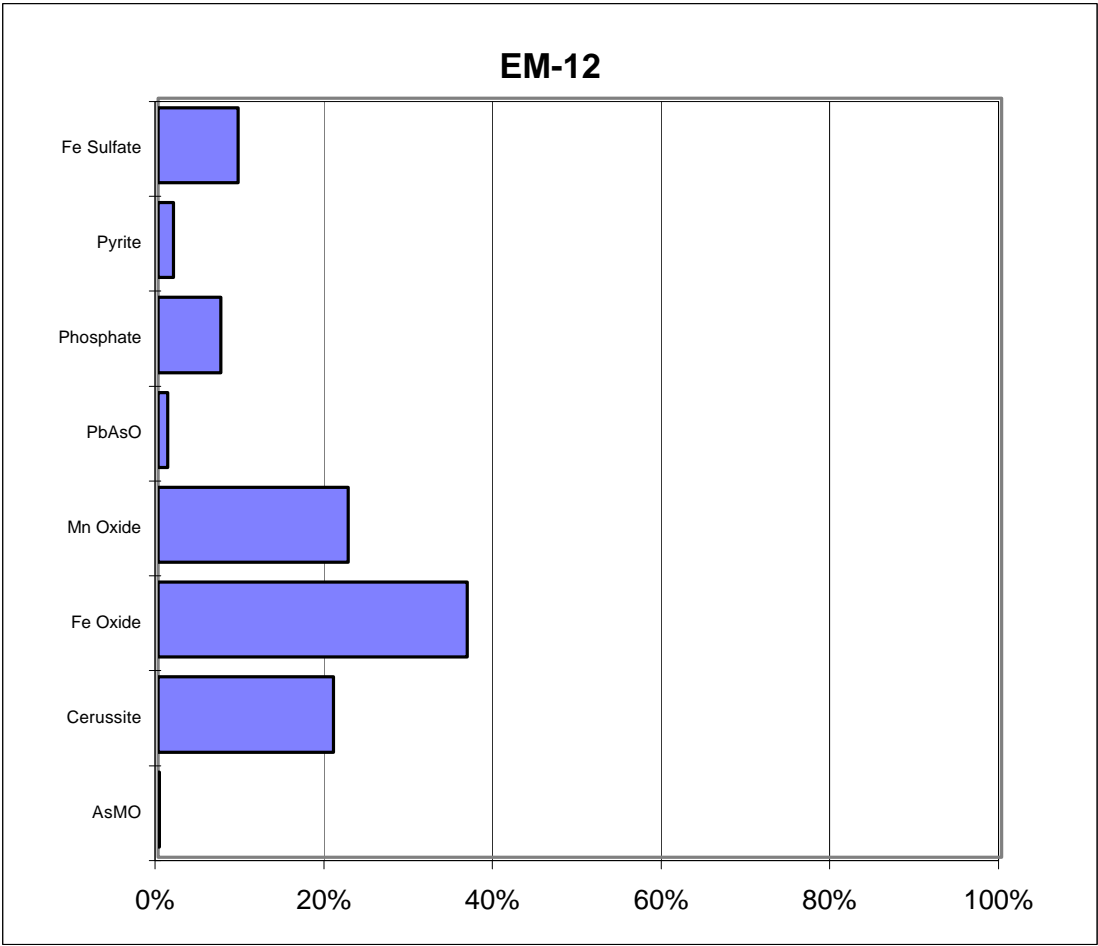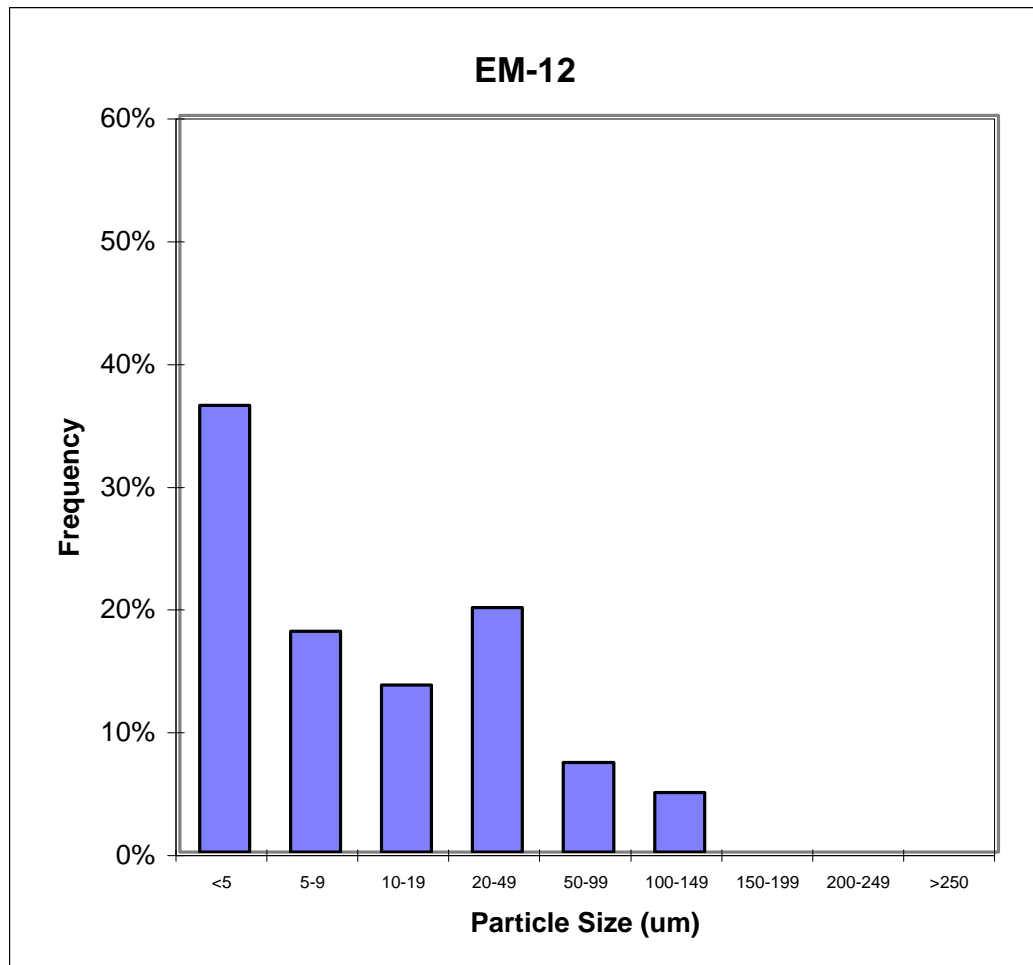
EM-12

FIGURE 1 PARTICLE SIZE DISTRIBUTION

RELATIVE ARSENIC MASS

EM-12

Fe Sulfate
Pyrite
Phosphate
PbAsO
Mn Oxide
Fe Oxide
Cerussite
AsMO

0%   20%   40%   60%   80%   100%

RELATIVE LEAD MASS

EM-12
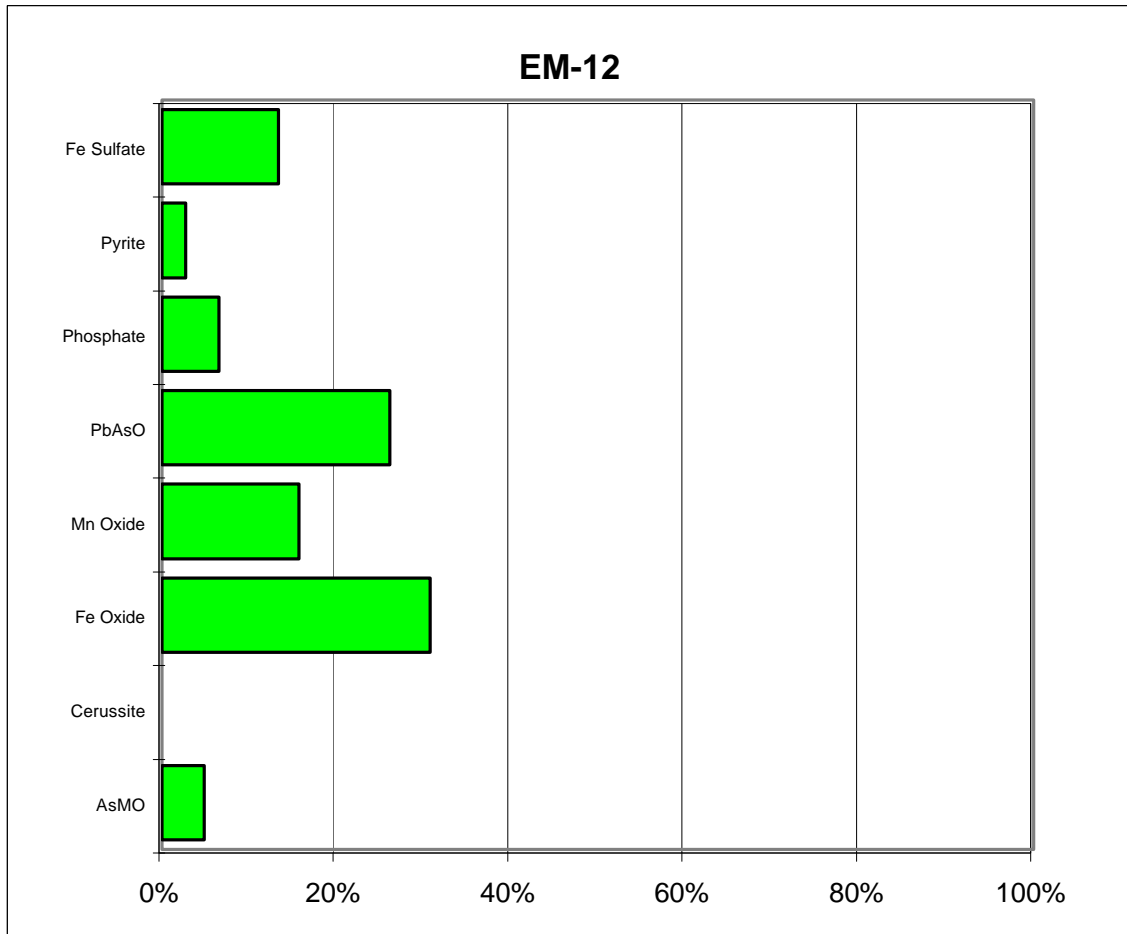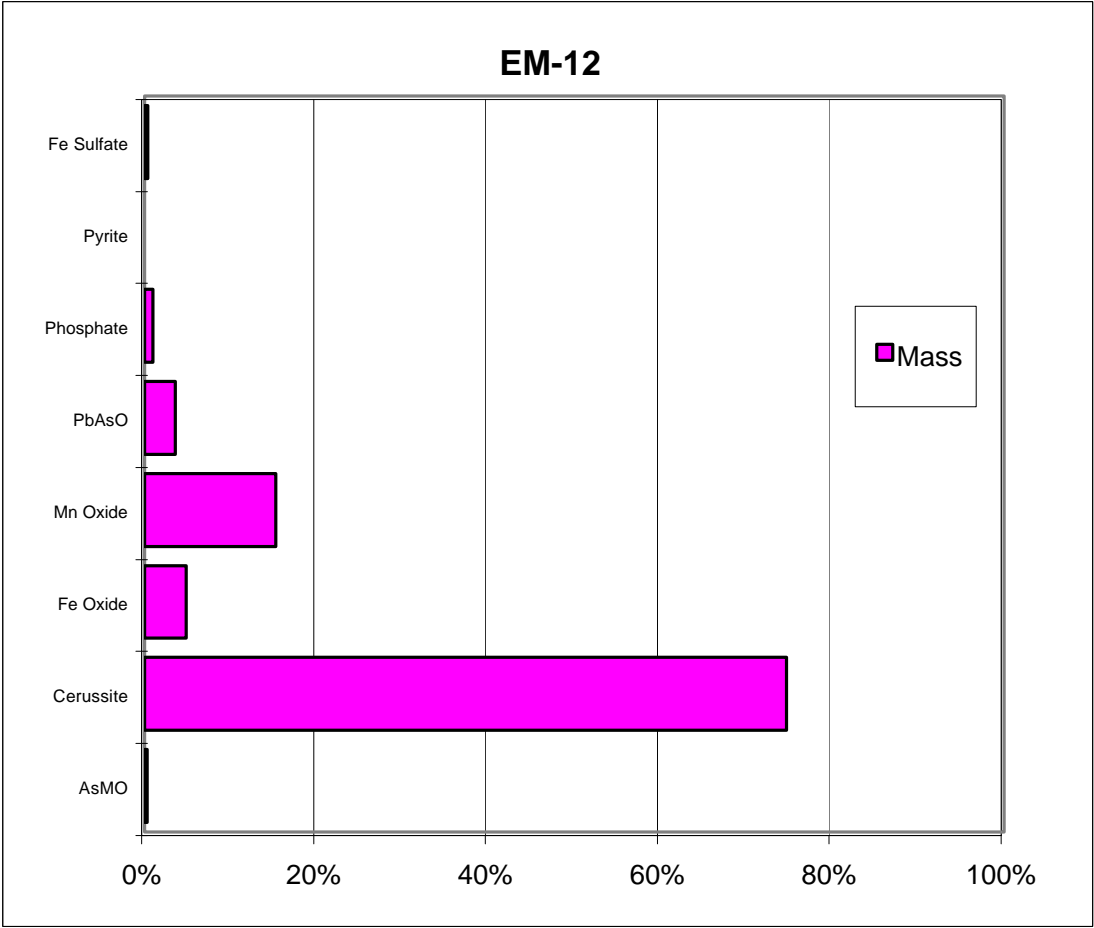
Summary

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
AsMO	0.2%	4.84%	0.2%	0.3%
Cerussite	20.8%	0.00%	20.8%	74.7%
Fe Oxide	36.7%	30.74%	36.7%	4.8%
Mn Oxide	22.5%	15.69%	22.5%	15.3%
PbAsO	1.1%	26.15%	1.1%	3.6%
Phosphate	7.4%	6.56%	7.4%	1.0%
Pyrite	1.8%	2.68%	1.8%	0.0%
Fe Sulfate	9.5%	13.35%	9.5%	0.4%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	36.4%	36.4%
5-9	18.0%	18.0%
10-19	13.6%	13.6%
20-49	19.9%	19.9%
50-99	7.3%	7.3%
100-149	4.9%	4.9%
150-199	0.0%	0.0%
200-249	0.0%	0.0%
≥250	0.0%	0.0%

SAMPLE ID EM-13

SUMMARY STATISTICS
EM-13 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract As	Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract As	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Anglesite	2	2	7	5	8	0.9%	0.9%	0.22%	0.22%	6.3	0	0.0%	0.0%	<5	38.4%	34.9%	1.6%	1.6%
Cerussite	130	120	13	1	540	56.8%	52.4%	27.38%	26.54%	6.6	0	0.0%	0.0%	5-9	16.6%	16.2%	2.0%	2.0%
Fe Oxide	19	19	59	9	165	8.3%	8.3%	18.94%	18.94%	4	0.011	17.4%	17.4%	10-19	12.2%	12.2%	2.9%	2.9%
Mn Oxide	1	1	24	24	24	0.4%	0.4%	0.40%	0.40%	5	0.0073	0.3%	0.3%	20-49	17.0%	16.6%	23.3%	23.3%
Pyrite	2	2	23	16	30	0.9%	0.9%	0.77%	0.77%	4.8	0.016	1.2%	1.2%	50-99	8.3%	8.3%	27.3%	27.3%
Fe Sulfate	75	75	41	3	200	32.8%	32.8%	52.28%	52.28%	3.7	0.02	81.0%	81.0%	100-149	6.1%	6.1%	35.0%	35.0%
														150-199	0.4%	0.4%	2.6%	2.6%
														200-249	0.4%	0.4%	5.2%	5.2%
														≥250	0.4%	0.4%	0.0%	0.0%
															100%	96%	100%	100%
TOTAL	229	219	26			100.0%	95.6%	100.00%	99.16%			100.0%	100.0%					

SUMMARY STATISTICS
EM-13 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Lead Mass (%)			DISTRIBUTION			
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract Pb	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Anglesite	2	2	7	5	8	0.9%	0.9%	0.22%	0.22%	6.3	0.684	0.6%	0.6%	<5	38.4%	34.9%	10.2%	9.1%
Cerussite	130	120	13	1	540	56.8%	52.4%	27.38%	26.54%	6.6	0.776	94.8%	91.9%	5-9	16.6%	16.2%	10.0%	9.7%
Fe Oxide	19	19	59	9	165	8.3%	8.3%	18.94%	18.94%	4	0.047	2.4%	2.4%	10-19	12.2%	12.2%	13.0%	13.0%
Mn Oxide	1	1	24	24	24	0.4%	0.4%	0.40%	0.40%	5	0.193	0.3%	0.3%	20-49	17.0%	16.6%	14.6%	13.2%
Pyrite	2	2	23	16	30	0.9%	0.9%	0.77%	0.77%	4.8	0.00007	0.0%	0.0%	50-99	8.3%	8.3%	12.9%	12.9%
Fe Sulfate	75	75	41	3	200	32.8%	32.8%	52.28%	52.28%	3.7	0.0146	1.9%	1.9%	100-149	6.1%	6.1%	7.3%	7.3%
														150-199	0.4%	0.4%	0.4%	0.4%
														200-249	0.4%	0.4%	0.1%	0.1%
														≥250	0.4%	0.4%	31.5%	31.5%
															100%	96%	100%	97%

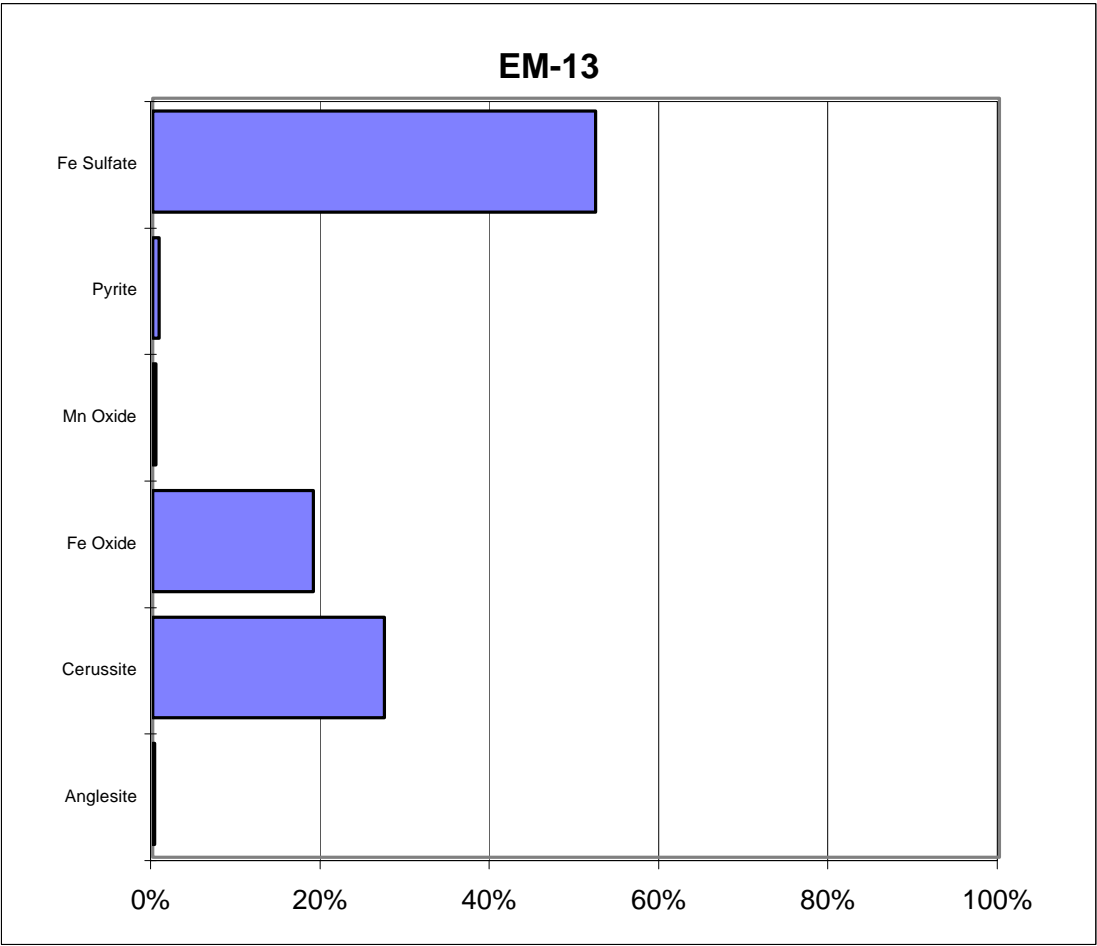# MINERAL FREQUENCY OBSERVED IN SITE SOIL
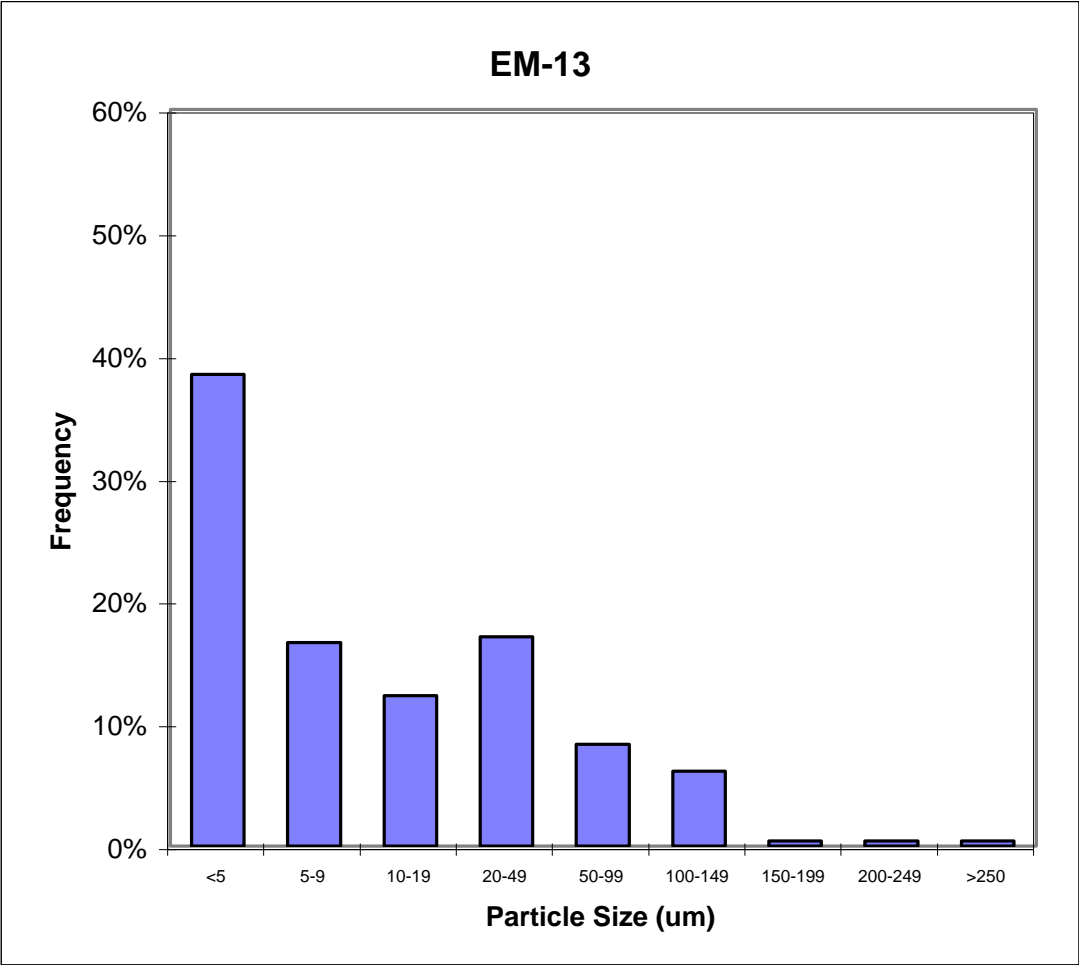
EM-13

FIGURE 1 PARTICLE SIZE DISTRIBUTION

RELATIVE ARSENIC MASS

EM-13

RELATIVE LEAD MASS

EM-13
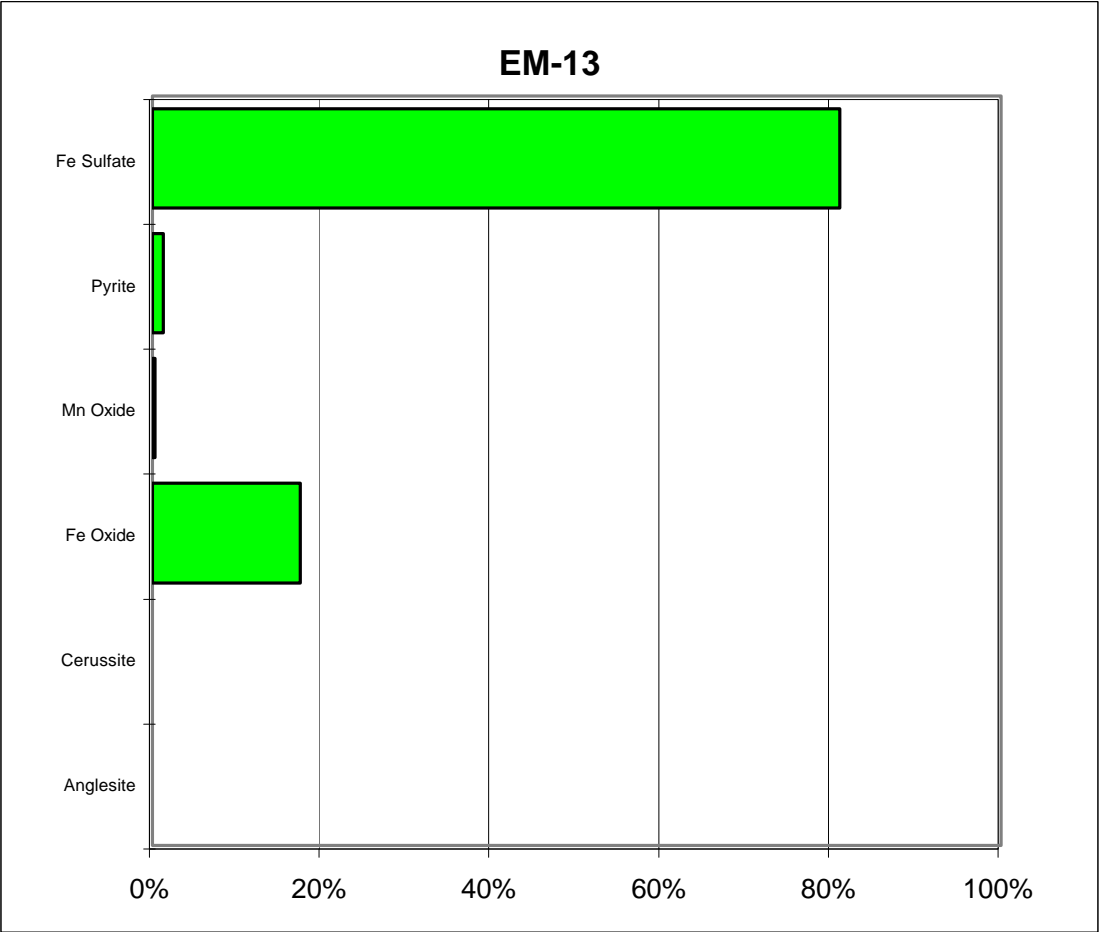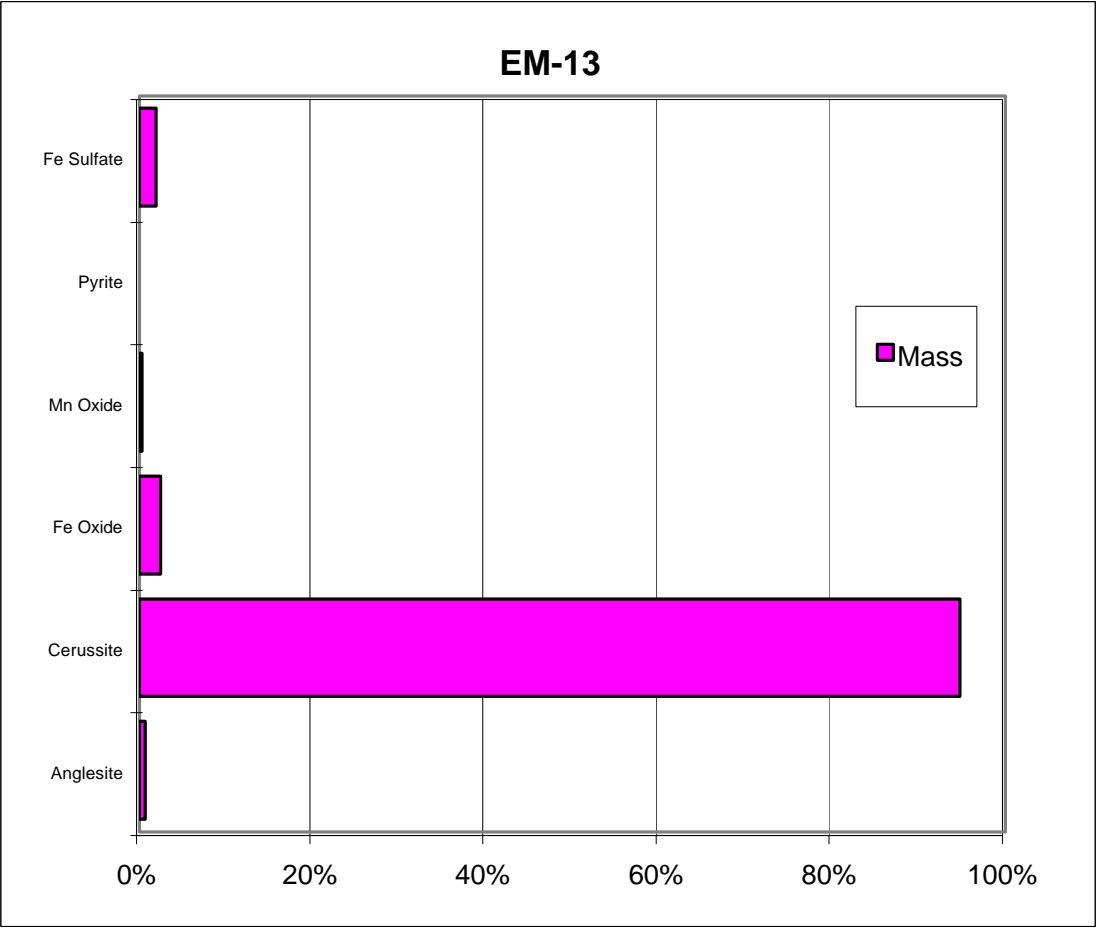
Summary

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Anglesite	0.2%	0.00%	0.2%	0.6%
Cerussite	27.4%	0.00%	27.4%	94.8%
Fe Oxide	18.9%	17.45%	18.9%	2.4%
Mn Oxide	0.4%	0.31%	0.4%	0.3%
Pyrite	0.8%	1.25%	0.8%	0.0%
Fe Sulfate	52.3%	81.00%	52.3%	1.9%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	38.4%	38.4%
5-9	16.6%	16.6%
10-19	12.2%	12.2%
20-49	17.0%	17.0%
50-99	8.3%	8.3%
100-149	6.1%	6.1%
150-199	0.4%	0.4%
200-249	0.4%	0.4%
≥250	0.4%	0.4%

SAMPLE ID EM-14

SUMMARY STATISTICS
EM-14 - Arsenic

Mineral	COUNTS			SIZE			Count Freq (%)		LW Freq (%)				Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max		Total	Liberated	Total	Liberated	Density	Fract As	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Clays	2	2	139	128	150		1.9%	1.9%	8.66%	8.66%	3.1	0.00028	0.2%	0.2%	<5	23.1%	11.1%	0.0%	0.0%
Anglesite	4	4	26	12	40		3.7%	3.7%	3.21%	3.21%	6.3	0	0.0%	0.0%	5-9	10.2%	10.2%	0.3%	0.3%
Cerussite	57	52	20	1	105		52.8%	48.1%	35.13%	33.95%	6.6	0	0.0%	0.0%	10-19	15.7%	14.8%	2.7%	2.7%
Fe Oxide	19	19	49	8	136		17.6%	17.6%	29.24%	29.24%	4	0.011	36.4%	36.4%	20-49	30.6%	29.6%	52.6%	52.6%
Fe AsO	1	1	26	26	26		0.9%	0.9%	0.81%	0.81%	4.5	0.338	34.8%	34.8%	50-99	13.9%	13.9%	34.5%	34.5%
Galena	10	0	2	1	4		9.3%	0.0%	0.72%	0.00%	7.5	0	0.0%	0.0%	100-149	5.6%	5.6%	9.8%	9.8%
Mn Oxide	4	4	55	30	90		3.7%	3.7%	6.85%	6.85%	5	0.0073	7.1%	7.1%	150-199	0.9%	0.9%	0.1%	0.1%
Organics	2	2	27	22	32		1.9%	1.9%	1.68%	1.68%	1.3	0	0.0%	0.0%	200-249	0.0%	0.0%	0.0%	0.0%
Slag	1	1	115	115	115		0.9%	0.9%	3.58%	3.58%	3.65	0.001	0.4%	0.4%	≥250	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	8	8	41	10	85		7.4%	7.4%	10.12%	10.12%	3.7	0.02	21.2%	21.2%					
																100%	86%	100%	100%
TOTAL	108	93	30				100.0%	86.1%	100.00%	98.10%			100.0%	100.0%					

SUMMARY STATISTICS
EM-14 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract Pb	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Clays	2	2	139	128	150	1.9%	1.9%	8.66%	8.66%	3.1	0.076	1.0%	1.0%	<5	23.1%	11.1%	4.5%	1.9%
Anglesite	4	4	26	12	40	3.7%	3.7%	3.21%	3.21%	6.3	0.684	6.5%	6.5%	5-9	10.2%	10.2%	5.5%	5.5%
Cerussite	57	52	20	1	105	52.8%	48.1%	35.13%	33.95%	6.6	0.776	84.3%	81.4%	10-19	15.7%	14.8%	11.1%	10.2%
Fe Oxide	19	19	49	8	136	17.6%	17.6%	29.24%	29.24%	4	0.047	2.6%	2.6%	20-49	30.6%	29.6%	43.2%	41.7%
Fe AsO	1	1	26	26	26	0.9%	0.9%	0.81%	0.81%	4.5	0.001	0.0%	0.0%	50-99	13.9%	13.9%	18.7%	18.7%
Galena	10	0	2	1	4	9.3%	0.0%	0.72%	0.00%	7.5	0.866	2.2%	0.0%	100-149	5.6%	5.6%	16.5%	16.5%
Mn Oxide	4	4	55	30	90	3.7%	3.7%	6.85%	6.85%	5	0.193	3.1%	3.1%	150-199	0.9%	0.9%	0.5%	0.5%
Organics	2	2	27	22	32	1.9%	1.9%	1.68%	1.68%	1.3	0.117	0.1%	0.1%	200-249	0.0%	0.0%	0.0%	0.0%
Slag	1	1	115	115	115	0.9%	0.9%	3.58%	3.58%	3.65	0.014	0.1%	0.1%	≥250	0.0%	0.0%	0.0%	0.0%
Fe Sulfate	8	8	41	10	85	7.4%	7.4%	10.12%	10.12%	3.7	0.0146	0.3%	0.3%					
															100%	86%	100%	95%

MINERAL FREQUENCY OBSERVED IN SITE SOIL
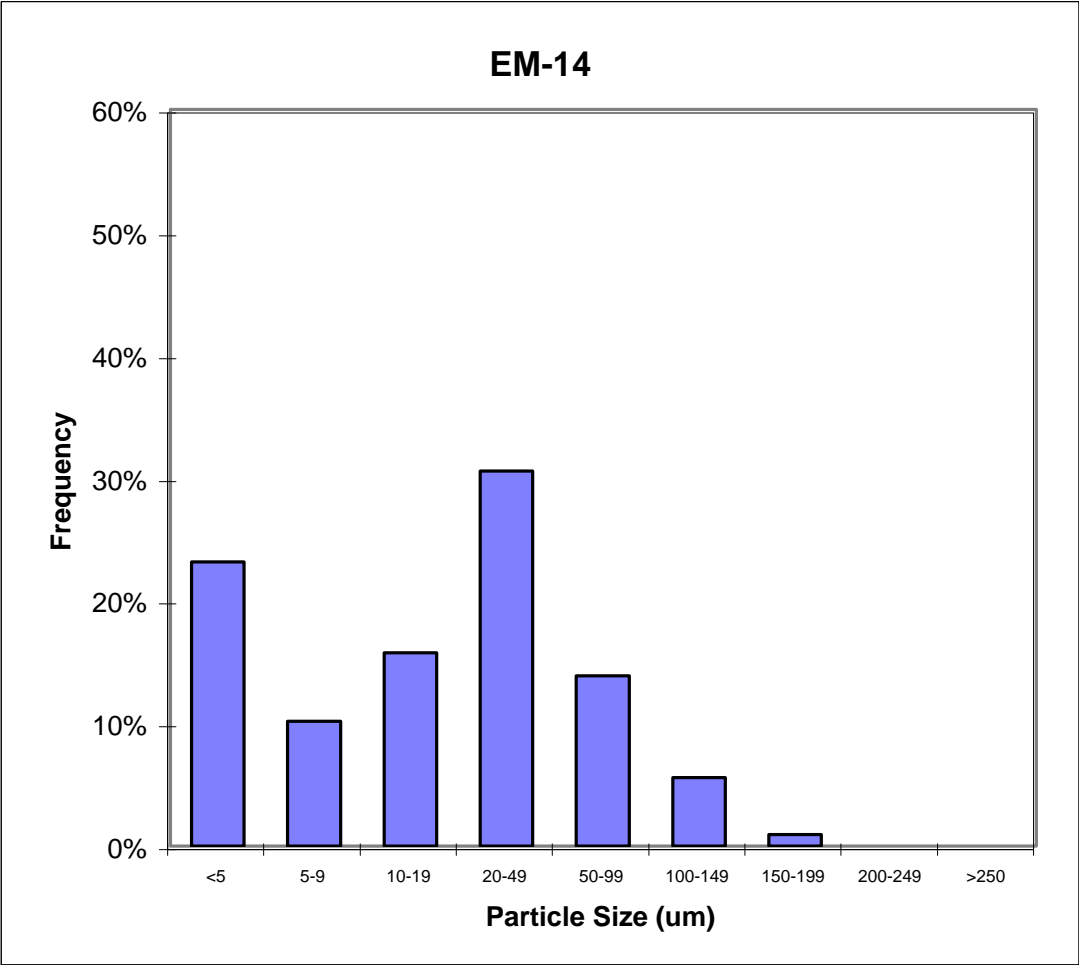
EM-14

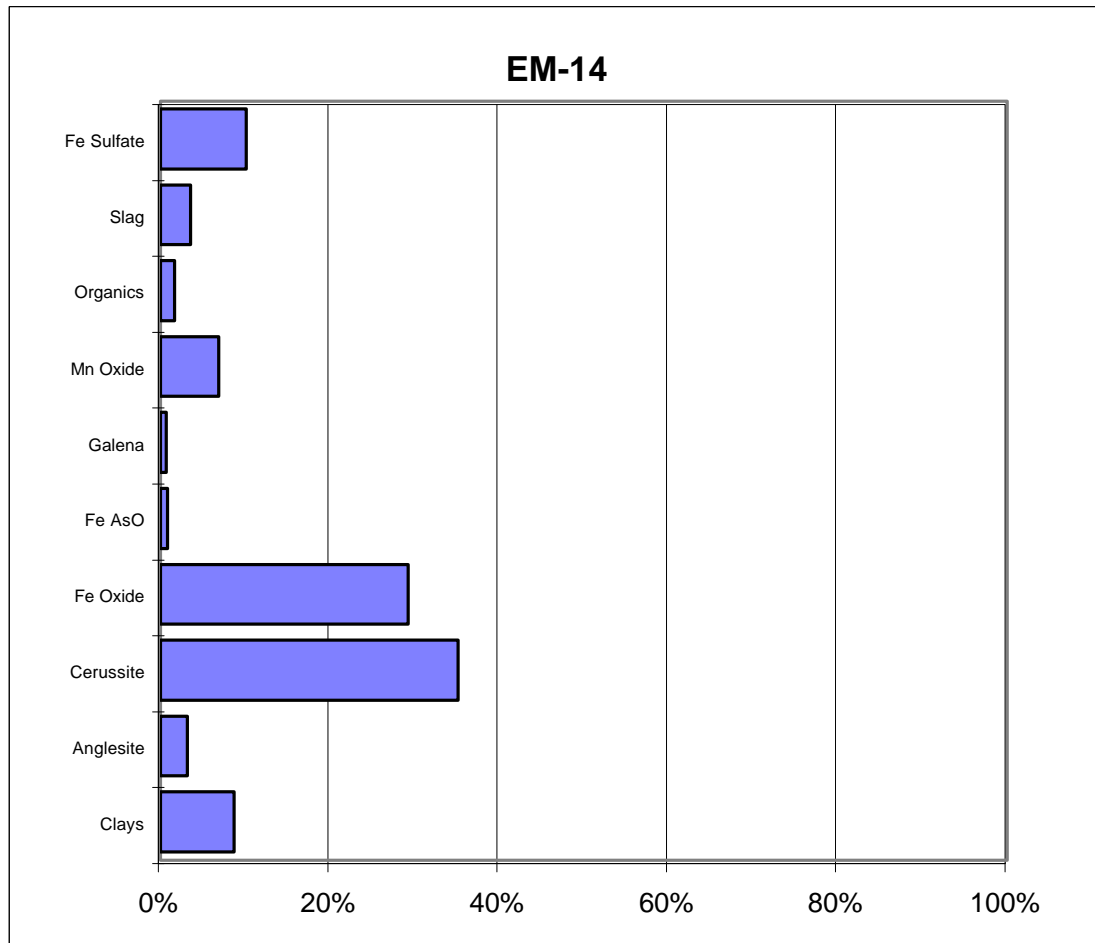# FIGURE 1 PARTICLE SIZE DISTRIBUTION

RELATIVE ARSENIC MASS

RELATIVE LEAD MASS

EM-14
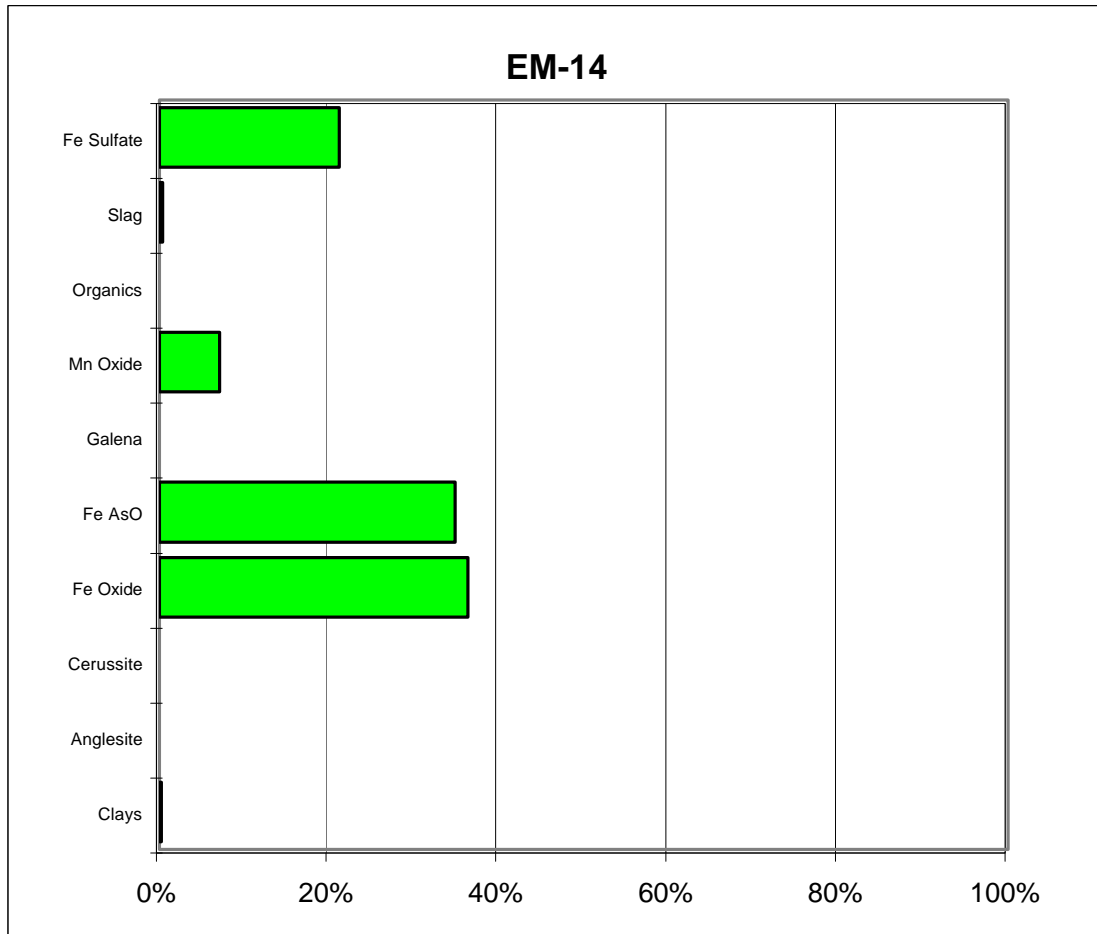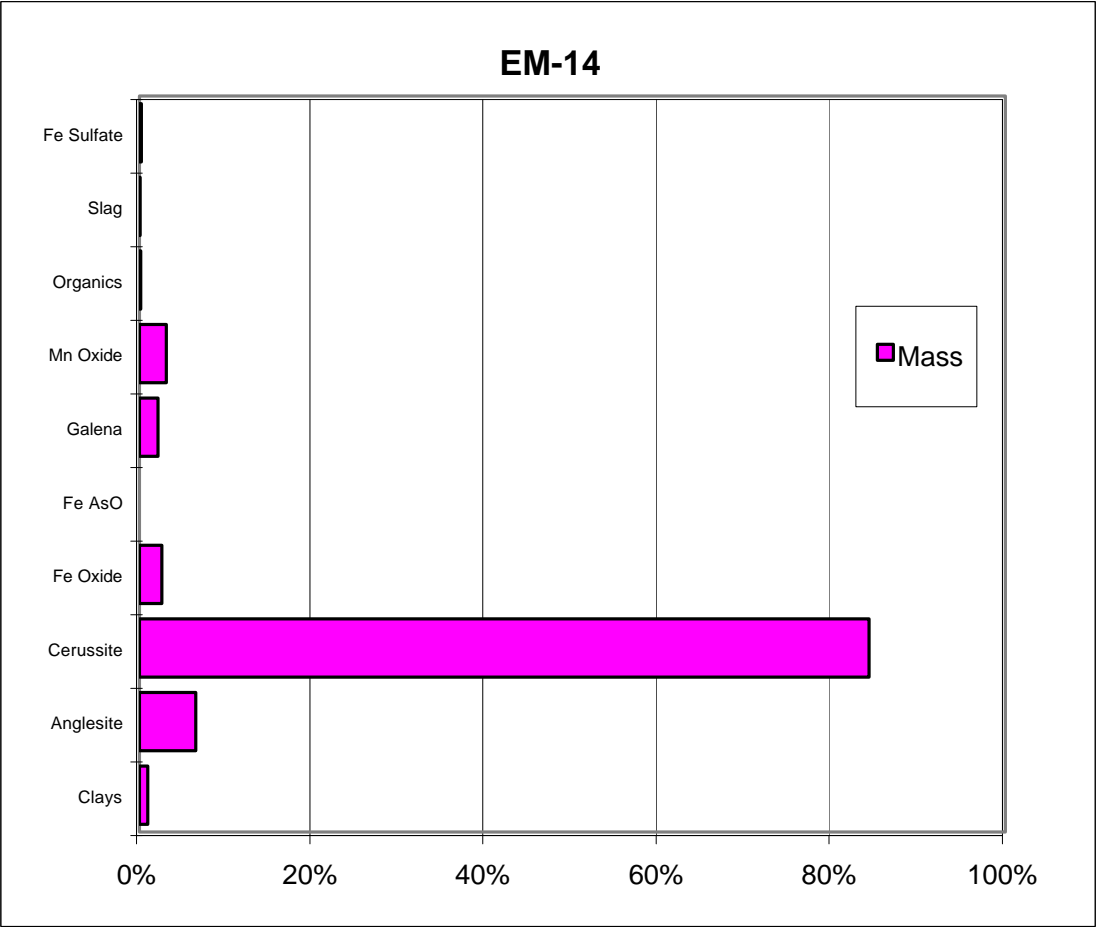
Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Clays	8.7%	0.21%	8.7%	1.0%
Anglesite	3.2%	0.00%	3.2%	6.5%
Cerussite	35.1%	0.00%	35.1%	84.3%
Fe Oxide	29.2%	36.37%	29.2%	2.6%
Fe AsO	0.8%	34.81%	0.8%	0.0%
Galena	0.7%	0.00%	0.7%	2.2%
Mn Oxide	6.9%	7.07%	6.9%	3.1%
Organics	1.7%	0.00%	1.7%	0.1%
Slag	3.6%	0.37%	3.6%	0.1%
Fe Sulfate	10.1%	21.17%	10.1%	0.3%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	23.1%	23.1%
5-9	10.2%	10.2%
10-19	15.7%	15.7%
20-49	30.6%	30.6%
50-99	13.9%	13.9%
100-149	5.6%	5.6%
150-199	0.9%	0.9%
200-249	0.0%	0.0%
$\geq$250	0.0%	0.0%

SAMPLE ID EM-15

SUMMARY STATISTICS
EM-15 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Arsenic Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract As	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	33	29	18	1	75	12.5%	11.0%	15.00%	14.90%	6.6	0	0.0%	0.0%	<5	73.9%	72.3%	12.3%	12.3%
Fe Oxide	127	127	14	1	125	48.1%	48.1%	45.60%	45.60%	4	0.011	45.0%	45.0%	5-9	5.3%	5.3%	1.5%	1.5%
Mn Oxide	7	7	61	9	112	2.7%	2.7%	11.10%	11.10%	5	0.0073	9.1%	9.1%	10-19	3.4%	3.4%	1.0%	1.0%
PbO	2	2	6	2	9	0.8%	0.8%	0.28%	0.28%	9.5	0	0.0%	0.0%	20-49	5.7%	5.7%	6.1%	6.1%
Phosphate	3	3	14	9	22	1.1%	1.1%	1.06%	1.06%	5	0.0093	1.1%	1.1%	50-99	6.4%	6.4%	31.4%	31.4%
Fe Sulfate	92	92	11	1	118	34.8%	34.8%	26.96%	26.96%	3.7	0.02	44.8%	44.8%	100-149	5.3%	5.3%	47.7%	47.7%
														150-199	0.0%	0.0%	0.0%	0.0%
														200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	98%	100%	100%
TOTAL	264	260	15			100.0%	98.5%	100.00%	99.90%			100.0%	100.0%					

SUMMARY STATISTICS
EM-15 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract Pb	Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated			Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	33	29	18	1	75	12.5%	11.0%	15.00%	14.90%	6.6	0.776	76.6%	76.1%	<5	73.9%	72.3%	4.8%	4.3%
Fe Oxide	127	127	14	1	125	48.1%	48.1%	45.60%	45.60%	4	0.047	8.5%	8.5%	5-9	5.3%	5.3%	9.2%	9.2%
Mn Oxide	7	7	61	9	112	2.7%	2.7%	11.10%	11.10%	5	0.193	10.7%	10.7%	10-19	3.4%	3.4%	10.1%	10.1%
PbO	2	2	6	2	9	0.8%	0.8%	0.28%	0.28%	9.5	0.93	2.5%	2.5%	20-49	5.7%	5.7%	32.5%	32.5%
Phosphate	3	3	14	9	22	1.1%	1.1%	1.06%	1.06%	5	0.037	0.2%	0.2%	50-99	6.4%	6.4%	32.7%	32.7%
Fe Sulfate	92	92	11	1	118	34.8%	34.8%	26.96%	26.96%	3.7	0.0146	1.5%	1.5%	100-149	5.3%	5.3%	10.7%	10.7%
														150-199	0.0%	0.0%	0.0%	0.0%
														200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	98%	100%	99%

MINERAL FREQUENCY OBSERVED IN SITE SOIL
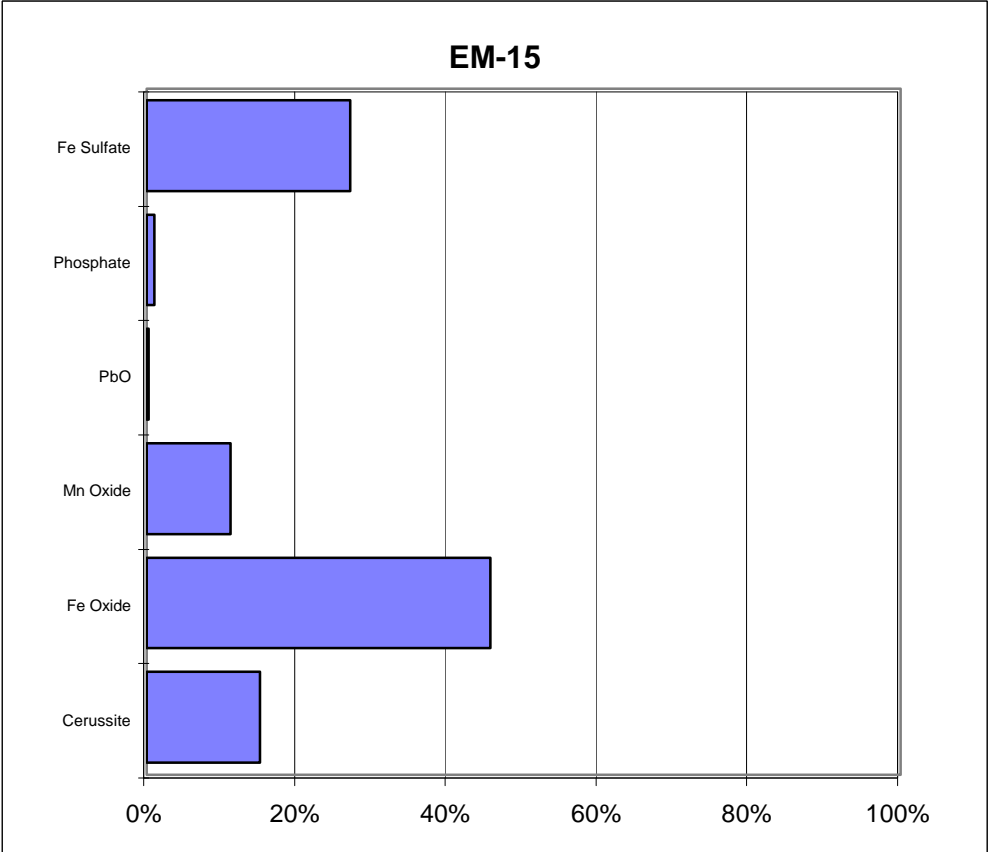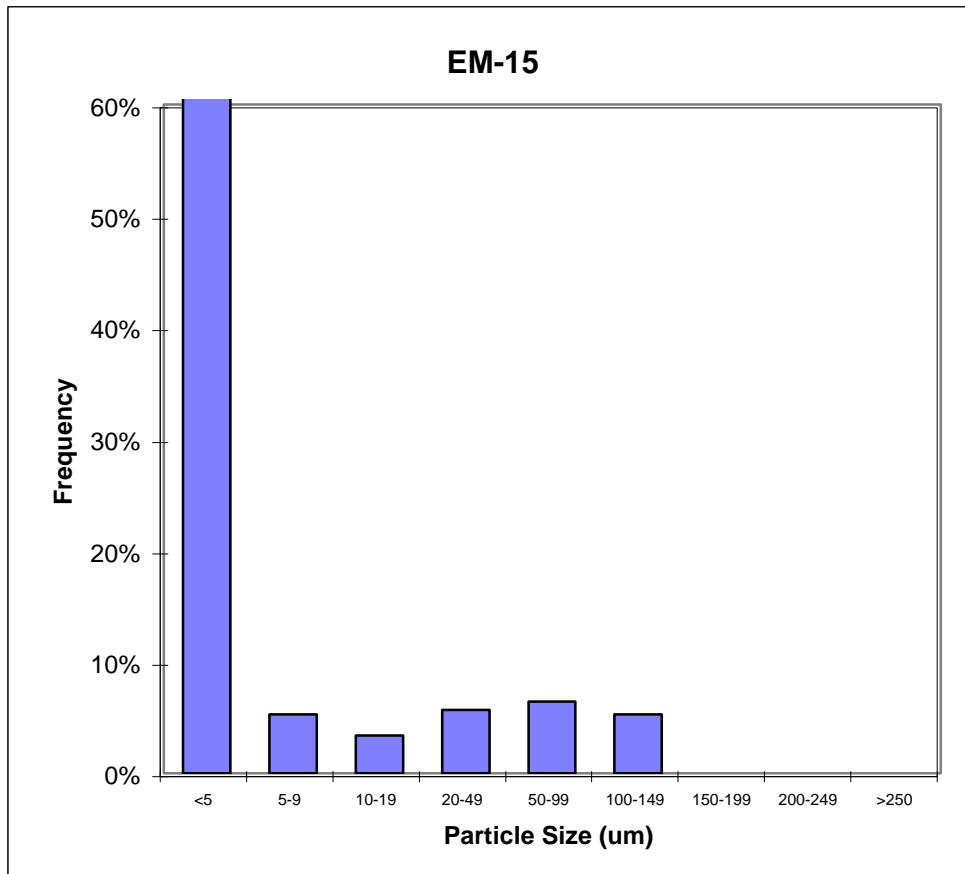
EM-15

FIGURE 1 PARTICLE SIZE DISTRIBUTION

EM-15

RELATIVE ARSENIC MASS

EM-15

RELATIVE LEAD MASS

EM-15
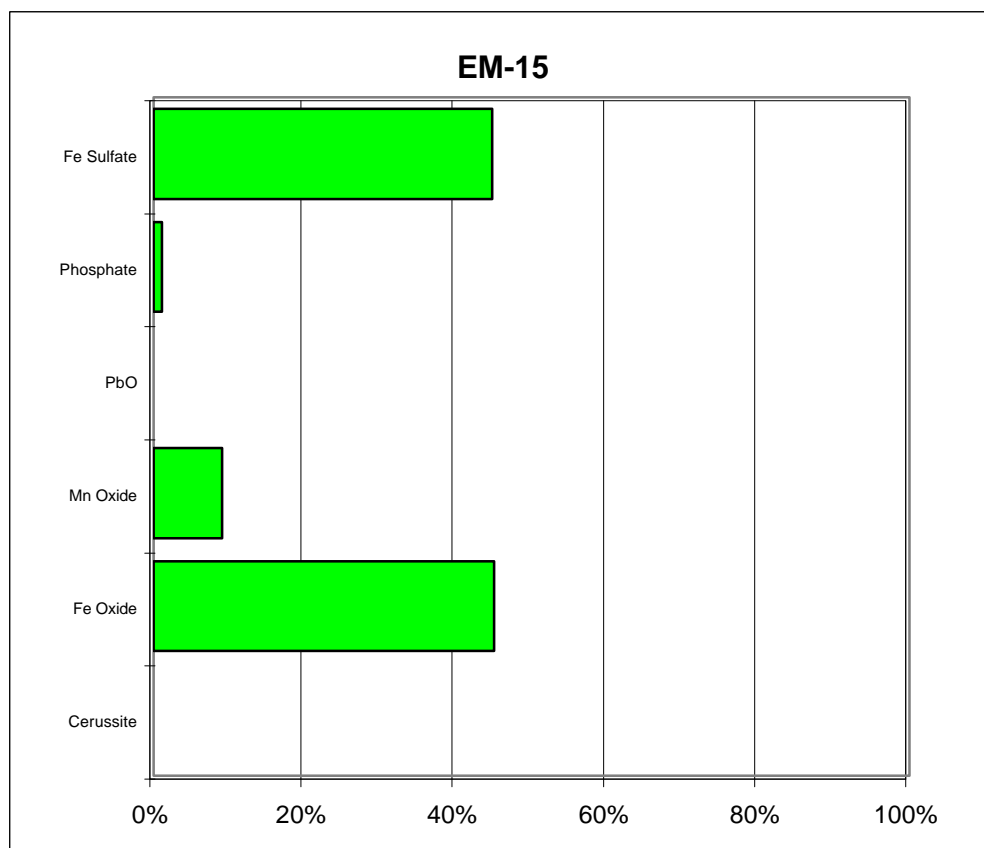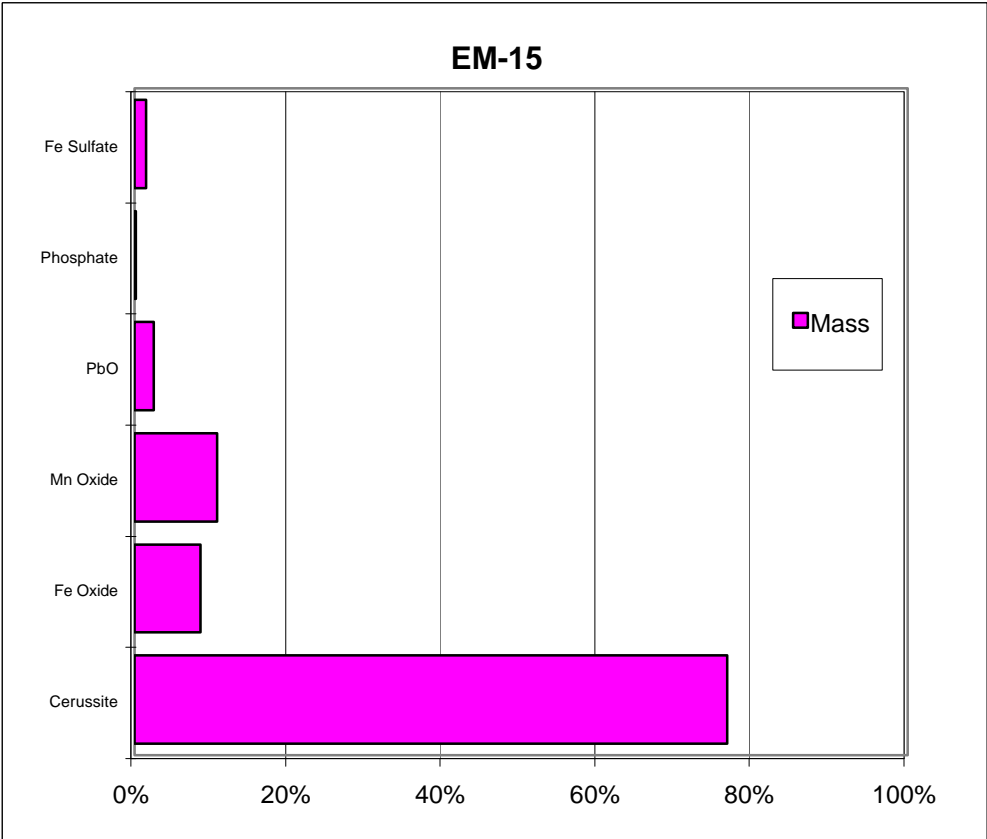
Summary

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Cerussite	15.0%	0.00%	15.0%	76.6%
Fe Oxide	45.6%	45.03%	45.6%	8.5%
Mn Oxide	11.1%	9.10%	11.1%	10.7%
PbO	0.3%	0.0%	0.3%	2.5%
Phosphate	1.1%	1.1%	1.1%	0.2%
Fe Sulfate	27.0%	44.77%	27.0%	1.5%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	73.9%	73.9%
5-9	5.3%	5.3%
10-19	3.4%	3.4%
20-49	5.7%	5.7%
50-99	6.4%	6.4%
100-149	5.3%	5.3%
150-199	0.0%	0.0%
200-249	0.0%	0.0%
≥250	0.0%	0.0%

SAMPLE ID EM-16

SUMMARY STATISTICS
EM-16 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract As	Relative Arsenic Mass (%)			DISTRIBUTION			
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated			Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	201	200	7	1	100	72.6%	72.2%	34.23%	34.00%	6.6	0	0.0%	0.0%	<5	67.1%	67.1%	3.4%	3.4%
Fe Oxide	60	60	28	2	145	21.7%	21.7%	43.29%	43.29%	4	0.011	59.6%	59.6%	5-9	7.9%	7.6%	2.1%	2.1%
Mn Oxide	5	5	75	13	170	1.8%	1.8%	9.68%	9.68%	5	0.0073	11.1%	11.1%	10-19	10.8%	10.8%	5.4%	5.4%
Phosphate	2	2	7	7	7	0.7%	0.7%	0.36%	0.36%	5	0.0093	0.5%	0.5%	20-49	4.0%	3.6%	6.0%	4.1%
Fe Sulfate	9	8	53	7	145	3.2%	2.9%	12.45%	11.62%	3.7	0.02	28.8%	26.9%	50-99	6.5%	6.5%	36.4%	36.4%
														100-149	3.2%	3.2%	41.6%	41.6%
														150-199	0.4%	0.4%	5.0%	5.0%
														200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	99%	100%	98%
TOTAL	277	275	14			100.0%	99.3%	100.00%	98.94%			100.0%	98.1%					

SUMMARY STATISTICS
EM-16 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract Pb	Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated			Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	201	200	7	1	100	72.6%	72.2%	34.23%	34.00%	6.6	0.776	90.6%	90.0%	<5	67.1%	67.1%	23.8%	23.8%
Fe Oxide	60	60	28	2	145	21.7%	21.7%	43.29%	43.29%	4	0.047	4.2%	4.2%	5-9	7.9%	7.6%	7.1%	6.5%
Mn Oxide	5	5	75	13	170	1.8%	1.8%	9.68%	9.68%	5	0.193	4.8%	4.8%	10-19	10.8%	10.8%	18.4%	18.4%
Phosphate	2	2	7	7	7	0.7%	0.7%	0.36%	0.36%	5	0.037	0.0%	0.0%	20-49	4.0%	3.6%	13.2%	13.2%
Fe Sulfate	9	8	53	7	145	3.2%	2.9%	12.45%	11.62%	3.7	0.0146	0.3%	0.3%	50-99	6.5%	6.5%	26.4%	26.4%
														100-149	3.2%	3.2%	8.9%	8.9%
														150-199	0.4%	0.4%	2.2%	2.2%
														200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															100%	99%	100%	99%

MINERAL FREQUENCY OBSERVED IN SITE SOIL
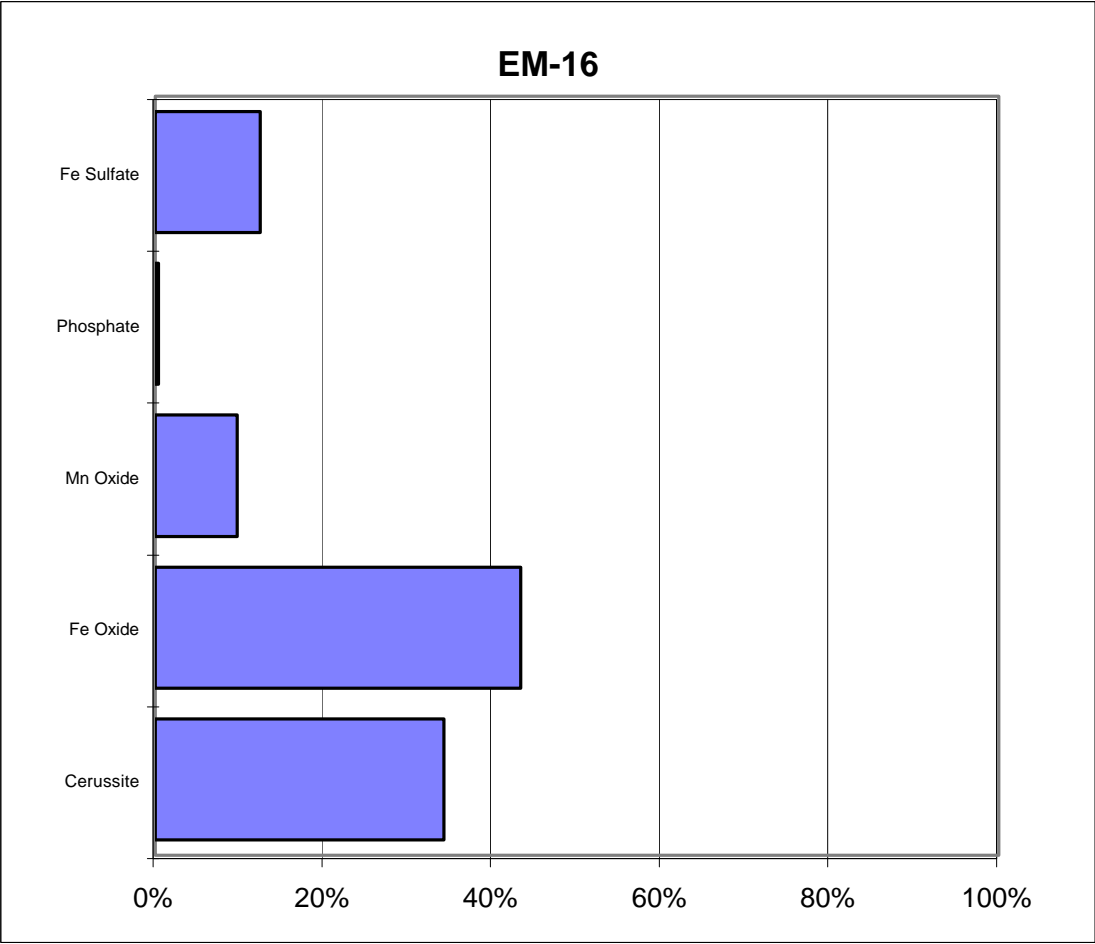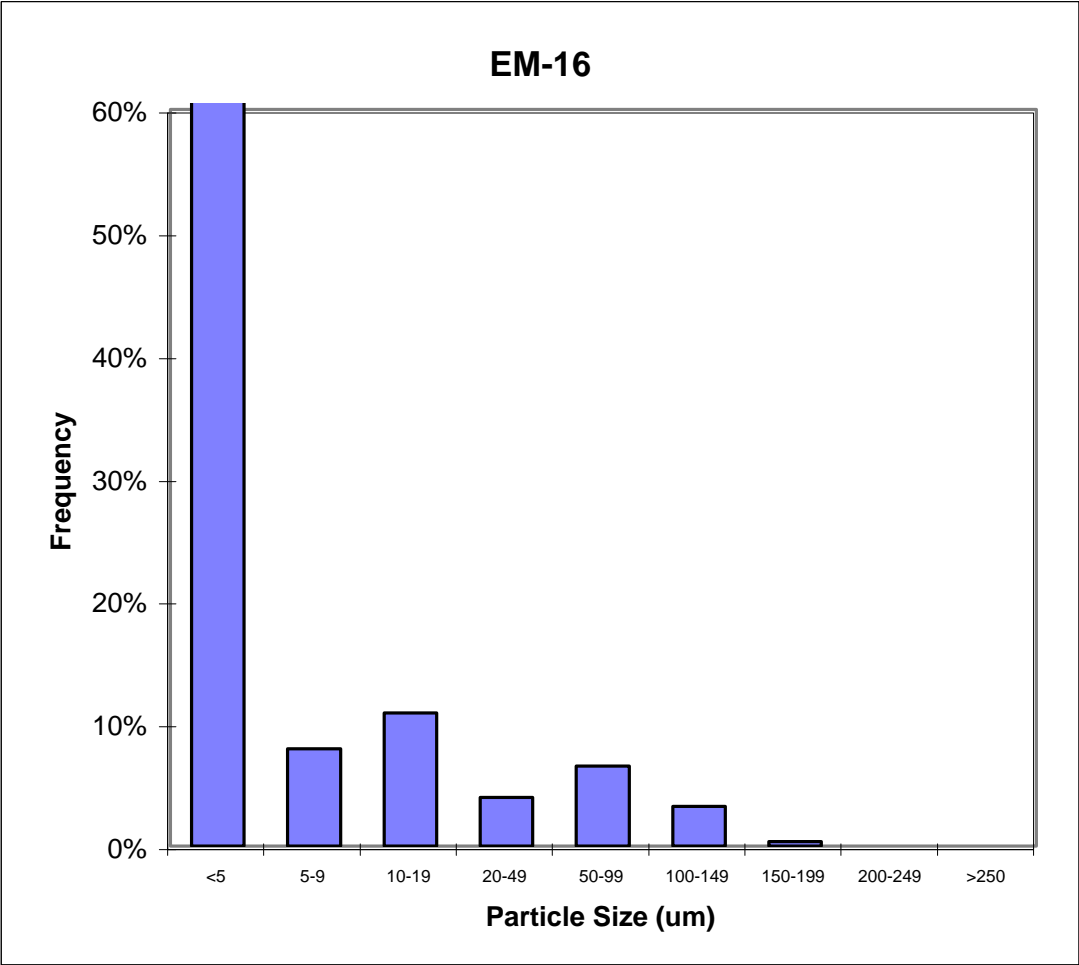
EM-16

FIGURE 1 PARTICLE SIZE DISTRIBUTION

EM-16

RELATIVE ARSENIC MASS

EM-16

RELATIVE LEAD MASS

EM-16
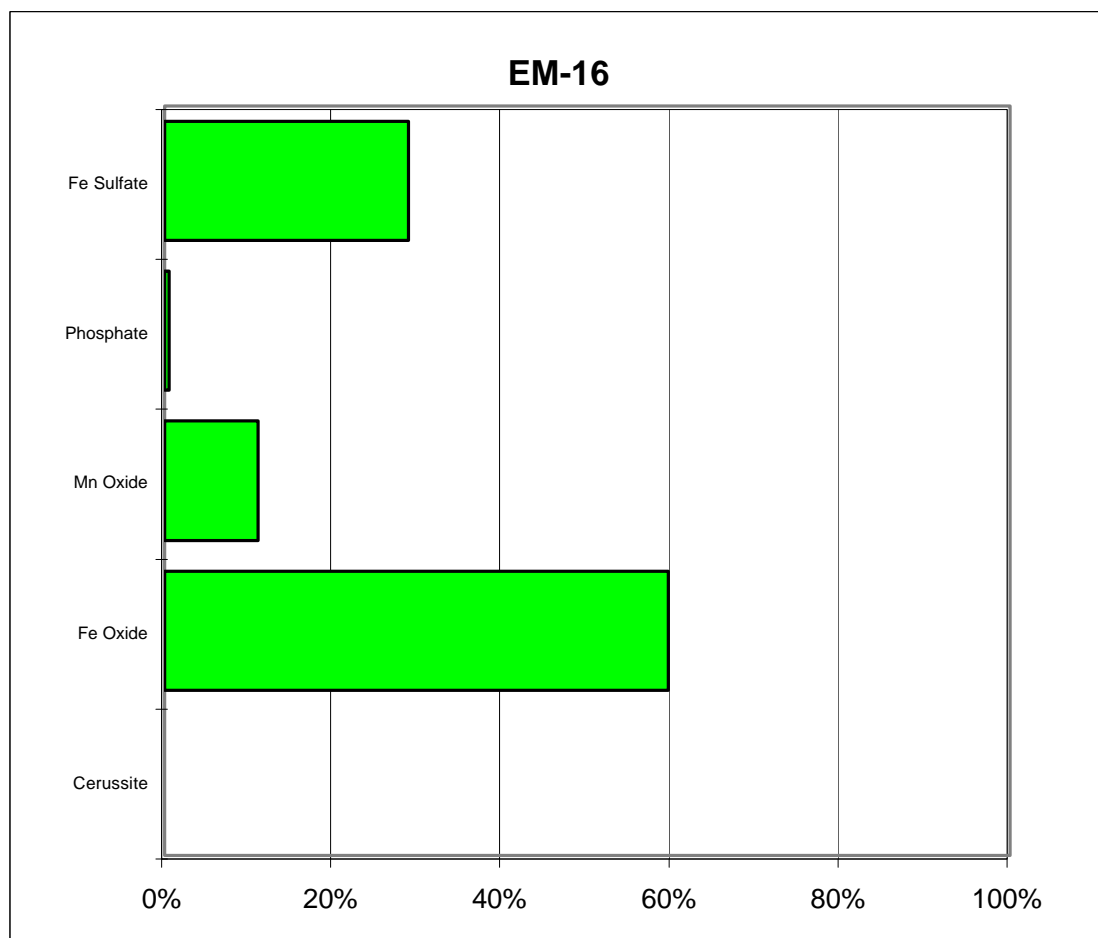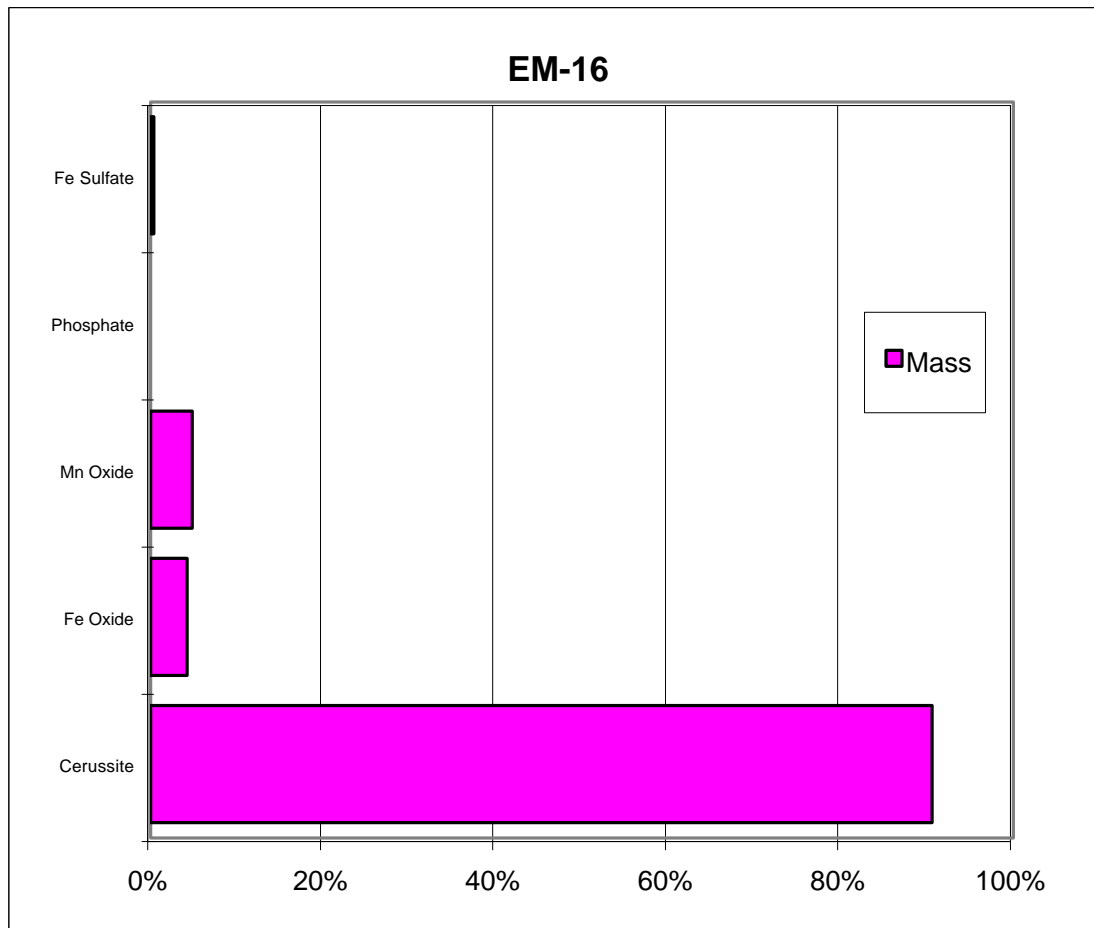
Summary

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Cerussite	34.2%	0.00%	34.2%	90.6%
Fe Oxide	43.3%	59.60%	43.3%	4.2%
Mn Oxide	9.7%	11.05%	9.7%	4.8%
Phosphate	0.4%	0.53%	0.4%	0.0%
Fe Sulfate	12.4%	28.82%	12.4%	0.3%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	67.1%	67.1%
5-9	7.9%	7.9%
10-19	10.8%	10.8%
20-49	4.0%	4.0%
50-99	6.5%	6.5%
100-149	3.2%	3.2%
150-199	0.4%	0.4%
200-249	0.0%	0.0%
≥250	0.0%	0.0%

SAMPLE ID EM-17

SUMMARY STATISTICS
EM-17 - Arsenic

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)		Density	Fract As	Relative Arsenic Mass (%)			DISTRIBUTION			
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated			Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	146	145	11	1	135	82.0%	81.5%	57.00%	56.78%	6.6	0	0.0%	0.0%	<5	52.8%	52.8%	0.0%	0.0%
Fe Oxide	25	25	35	8	80	14.0%	14.0%	32.83%	32.83%	4	0.011	75.5%	75.5%	5-9	17.4%	16.9%	2.5%	2.5%
Mn Oxide	5	5	41	8	110	2.8%	2.8%	7.61%	7.61%	5	0.0073	14.5%	14.5%	10-19	3.9%	3.9%	4.2%	4.2%
Fe Sulfate	2	2	35	14	55	1.1%	1.1%	2.56%	2.56%	3.7	0.02	9.9%	9.9%	20-49	15.7%	15.7%	35.9%	35.9%
														50-99	9.6%	9.6%	50.1%	50.1%
														100-149	1.1%	1.1%	7.2%	7.2%
														150-199	0.0%	0.0%	0.0%	0.0%
														200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															101%	100%	100%	100%
TOTAL	178	177	15			100.0%	99.4%	100.00%	99.78%			100.0%	100.0%					

SUMMARY STATISTICS
EM-17 - Lead

Mineral	COUNTS			SIZE		Count Freq (%)		LW Freq (%)				Relative Lead Mass (%)		DISTRIBUTION				
	Total	Lib	Avg	Min	Max	Total	Liberated	Total	Liberated	Density	Fract Pb	Total	Liberated	Size	Total Freq	Lib Freq	Total RAM	Lib RAM
Cerussite	146	145	11	1	135	82.0%	81.5%	57.00%	56.78%	6.6	0.776	95.5%	95.2%	<5	52.8%	52.8%	14.6%	14.6%
Fe Oxide	25	25	35	8	80	14.0%	14.0%	32.83%	32.83%	4	0.047	2.0%	2.0%	5-9	17.4%	16.9%	10.6%	10.2%
Mn Oxide	5	5	41	8	110	2.8%	2.8%	7.61%	7.61%	5	0.193	2.4%	2.4%	10-19	3.9%	3.9%	3.6%	3.6%
Fe Sulfate	2	2	35	14	55	1.1%	1.1%	2.56%	2.56%	3.7	0.0146	0.0%	0.0%	20-49	15.7%	15.7%	23.9%	23.9%
														50-99	9.6%	9.6%	37.7%	37.7%
														100-149	1.1%	1.1%	9.7%	9.7%
														150-199	0.0%	0.0%	0.0%	0.0%
														200-249	0.0%	0.0%	0.0%	0.0%
														≥250	0.0%	0.0%	0.0%	0.0%
															101%	100%	100%	100%

MINERAL FREQUENCY OBSERVED IN SITE SOIL
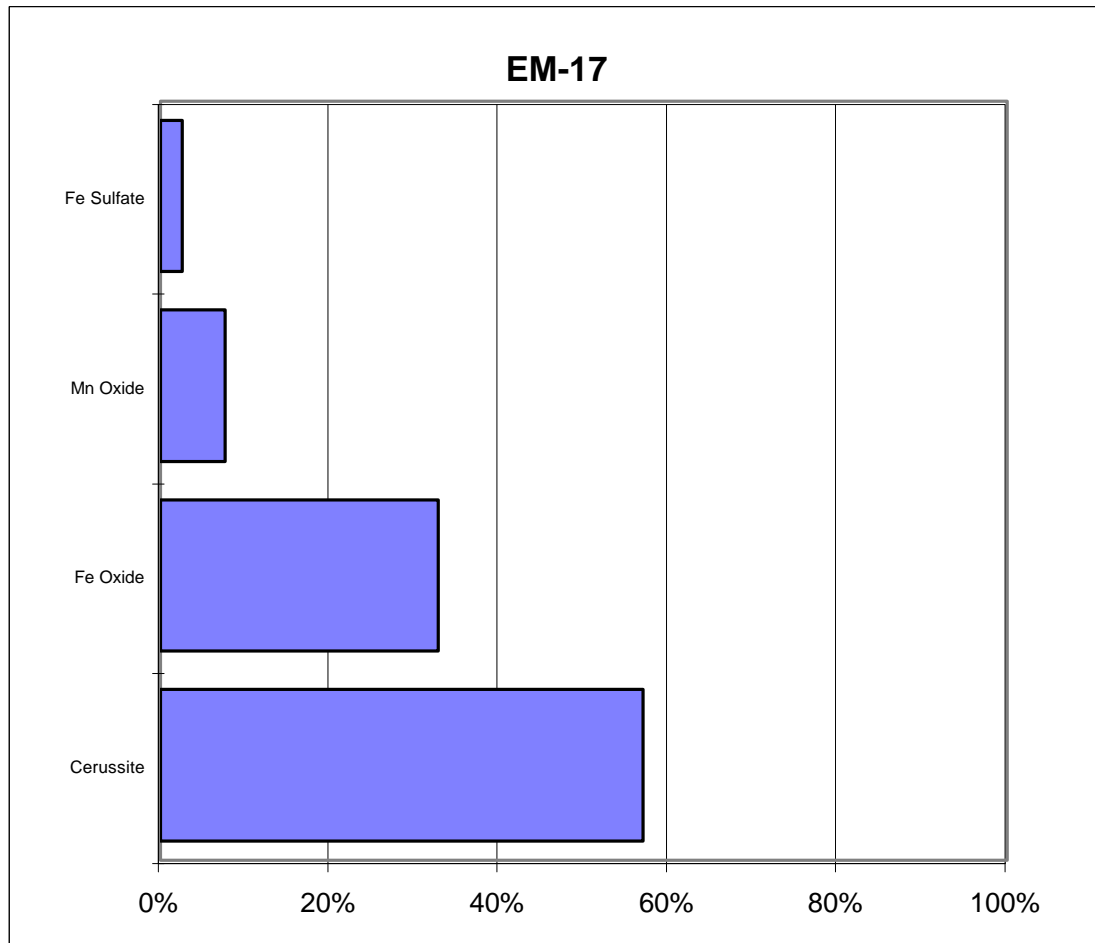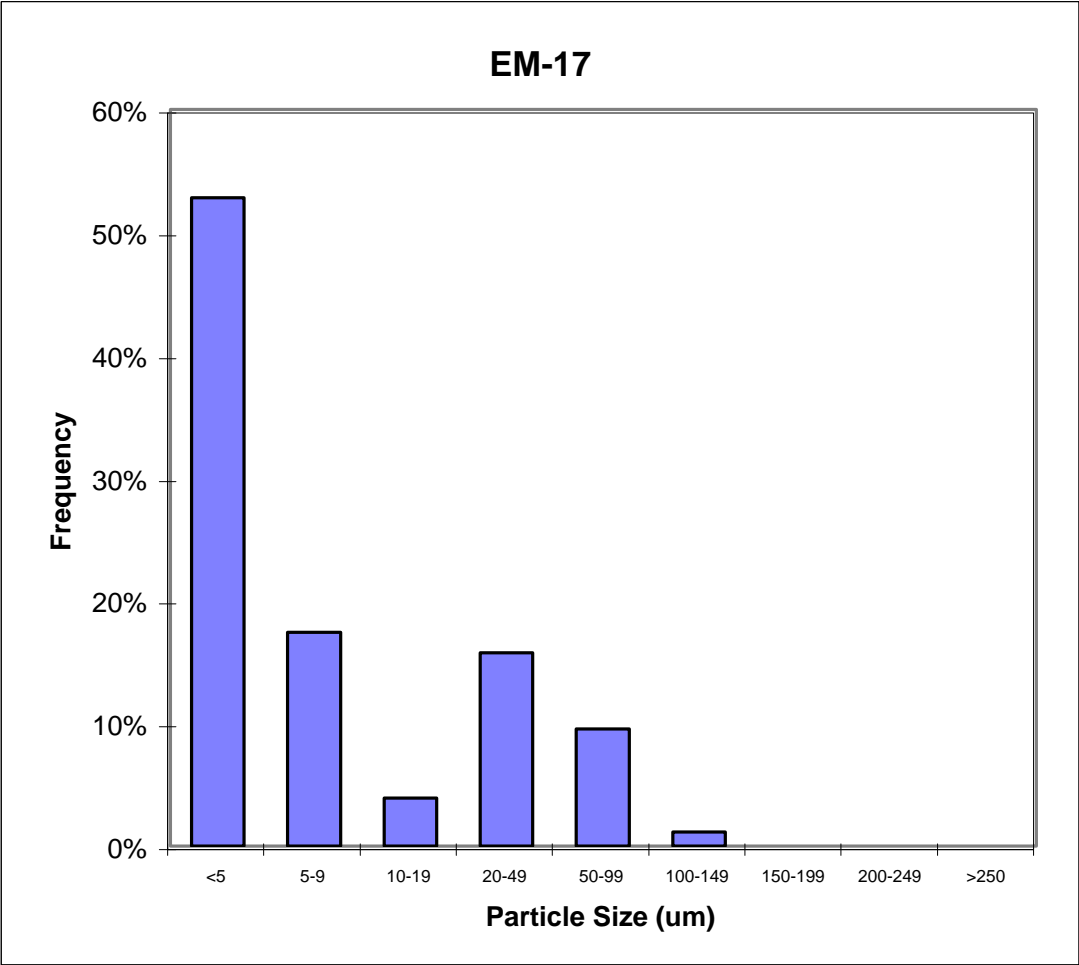
EM-17

FIGURE 1 PARTICLE SIZE DISTRIBUTION

RELATIVE ARSENIC MASS

EM-17
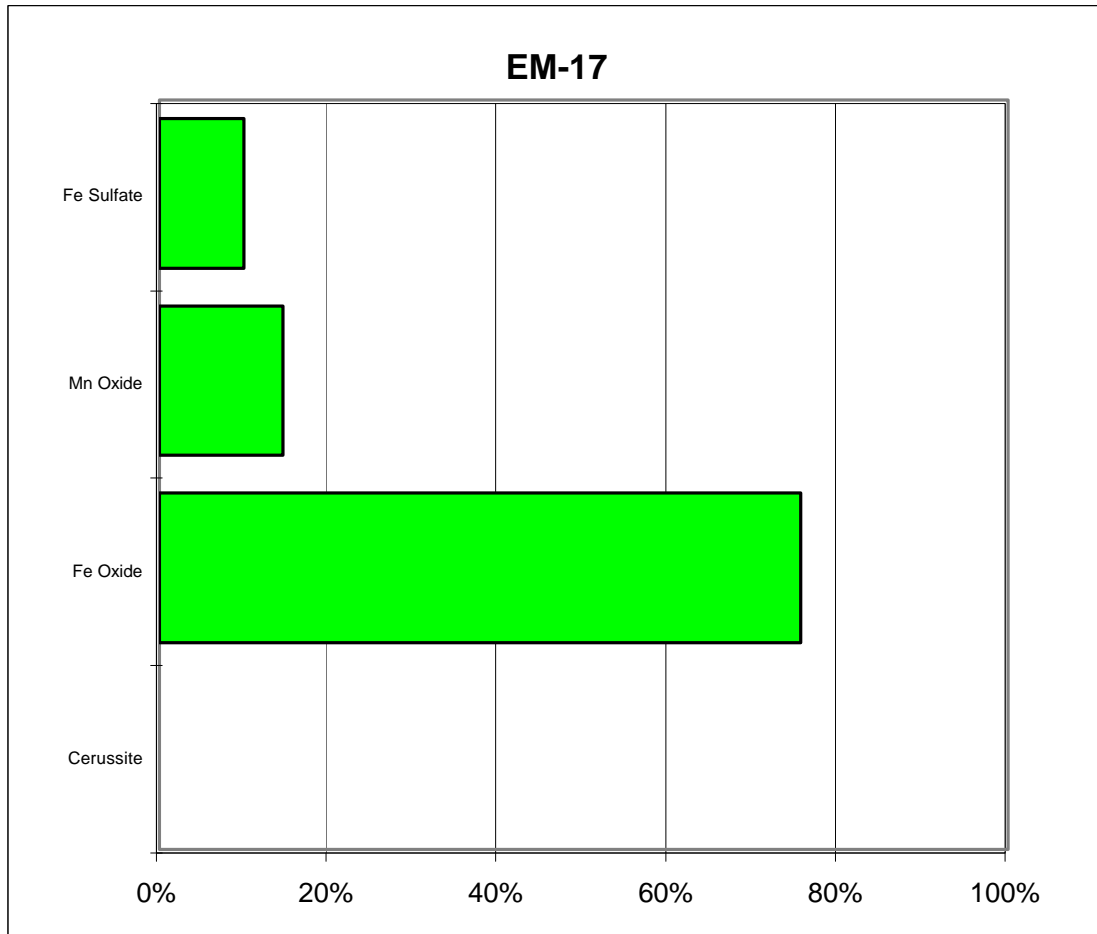
RELATIVE LEAD MASS
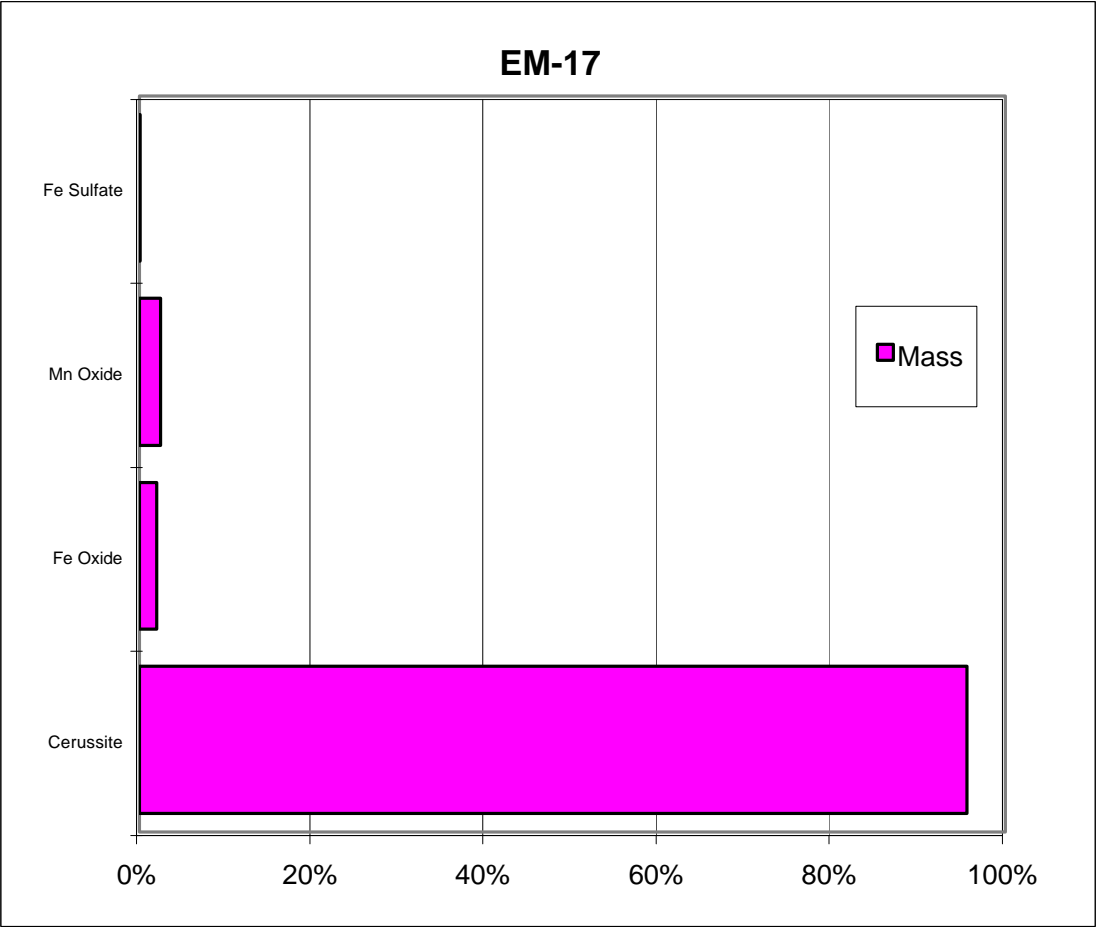
Summary

Mineral	Arsenic		Lead	
	Freq	Mass	Freq	Mass
Cerussite	57.0%	0.00%	57.0%	95.5%
Fe Oxide	32.8%	75.55%	32.8%	2.0%
Mn Oxide	7.6%	14.53%	7.6%	2.4%
Fe Sulfate	2.6%	9.92%	2.6%	0.0%
Total	100%	100%	100%	100%

Size	Arsenic	Lead
<5	52.8%	52.8%
5-9	17.4%	17.4%
10-19	3.9%	3.9%
20-49	15.7%	15.7%
50-99	9.6%	9.6%
100-149	1.1%	1.1%
150-199	0.0%	0.0%
200-249	0.0%	0.0%
$\geq$250	0.0%	0.0%

APPENDIX C
SCREENING CALCULATIONS FOR DERMAL, INHALATION, AND HOMEGROWN VEGETABLE EXPOSURES

APPENDIX C

SCREENING LEVEL EVALUATION OF RELATIVE RISK FROM INHALATION OF DUST AND DERMAL CONTACT WITH SOIL

1.0 EXPOSURE VIA INHALATION OF PARTICULATES IN AIR

The basic equation recommended by EPA (1989a) for evaluation of inhalation exposure is:

$$DI_{air} = C_a \times BR_a \times EF \times ED / (BW \times AT)$$

where:

DI_{air}	=	Daily intake from air (mg/kg-d)
C_a	=	Concentration of substance in air (mg/m^3)
BR_a	=	Breathing rate of air (m^3/day)
EF	=	Exposure frequency (days/yr)
ED	=	Exposure duration (yrs)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

Recommended data defaults are as summarized below.

Parameter	Source Documents	Typical RME Values for Residential Adult[a]
BR	RAGS (EPA 1989b)	20 m^3/day
EF	RAGS Supplemental Guidance (EPA 1991)	350 days/yr
ED	RAGS Supplemental Guidance (EPA 1991)	30 years
BW	RAGS (EPA 1989b)	70 kg
AT	RAGS (EPA 1989b) RAGS Supplemental Guidance (EPA 1991)	30 years (noncancer) 70 years (cancer)

The relative magnitude of the inhaled dose of a COPC from air can be compared to the ingested dose from soil as follows:

$$\frac{DI_{air}}{DI_{oral}} = \frac{C_{air} \cdot BR_a}{C_s \cdot IR_s}$$

where:

DI_{air} = Daily intake from air (mg/kg-d)
C_a = Concentration of substance in air (mg/m^3)
BR_a = Breathing rate of air (m^3/day)
C_s = Concentration in soil
IR_s = Ingestion rate of soil (kg/day)

The EPA recommends a screening level soil to air transfer factor of 7.6E-10 kg/m^3 (EPA 1996) and a soil ingestion rate by adults of 100 mg/day (1E-04 kg/day) (EPA 1991b). Based on these values, the ratio of the mass of soil inhaled to that ingested is:

$$\frac{DI_{air}}{DI_{oral}} = \frac{7.6E-10 \ kg/m^3 \cdot 20 \ m^3/day}{1E-04 \ kg/day} = 1.5E-05 \ (0.015\%)$$

As seen, the inhaled dose of soil is very small compared to the ingested dose, so the inhalation pathway is not considered to be of significant concern at this site.

2.0 DERMAL EXPOSURE VIA SOIL

The basic equation recommended for estimation of dermal dose from contact with soils is as follows (EPA 1989b, 1992):

$$AD_{soil} = C_s \times SA \times AF \times ABS \times EF \times ED/(BW \times AT)$$

where:

C_s = concentration of chemical in soil (mg/kg)
SA = surface area in contact with soil (cm^2)
AF = soil adherence factor (kg/cm^2)
ABS = absorption fraction (unitless)

At the present time, data are very limited on the value of the ABS term, and the EPA (1992) has concluded that there are only three chemicals for which sufficient data exist to estimate credible ABS values, as shown below:

Chemical	ABS
Dioxins	0.1-3%
PCBs	0.6-6%
Cadmium	0.1-1%

It is important to realize that even these values are rather uncertain, due to a variety of differences between the exposure conditions used in laboratory studies of dermal absorption and exposure conditions that are likely to occur at Superfund sites. For example, most laboratory studies use much higher soil loadings on the skin (e.g., 5-50 mg/cm^2) than are expected to occur at sites (0.2-1 mg/cm^2). Also, most studies investigate the amount absorbed after a relatively lengthy contact period (16-96 hours), while it is expected that most people would wash off soil on the skin more promptly than this. Because of these difficulties in extrapolation from experimental measurements to "real-life" conditions, the values above are only considered approximate, and are more likely to be high than low. With respect to estimating ABS values for other chemicals (those for which there are no reliable experimental measurements), the EPA concludes that current methods are not sufficiently developed to calculate values from available data such as physical-chemical properties.

If values of ABS were available for the site COPCs, the relative magnitude of the dermal dose to the oral dose would be calculated as follows:

$$\frac{AD_d}{AD_o} = \frac{SA \cdot AF \cdot ABS \cdot EF_d}{IR \cdot AF_o \cdot EF_o}$$

where:

SA	=	surface area in contact with soil (cm^2)
AF	=	soil adherence factor (kg/cm^2)
ABS	=	absorption fraction (unitless)
IR$_w$	=	Ingestion rate of water (cm^3/day)
AF$_o$	=	Oral absorption fraction
EF$_d$	=	Dermal exposure frequency (days/yr)
EF$_o$	=	Dermal exposure frequency (days/yr)

Assuming that 10% of the body area (2,000 cm^2) is covered with soil (1 mg/cm^2 = 1E-06 kg/cm^2) for 50 days/yr, the ratio of the predicted dermal absorbed dose to the oral absorbed dose is given by:

$$\frac{AD_d}{AD_o} = 2.86 \frac{ABS}{AF_o}$$

If, by extrapolation from cadmium, the ABS is assumed to be 0.1-1% for site COPCs, then the ratio of dermal dose from soil to oral dose from soil are as follows:

Chemical	ABS (assumed)	AFo	Dose Ratio (dermal/oral)
Non-Lead COPCs	0.001-0.01	1	0.3-3%
Lead	0.001-0.01	0.1	3-28%

Because the value of ABS is not available for the site COPCs, these values should not be considered to be reliable. However, this calculation does support the conclusion that dermal absorption of metals from dermal contact with soil is likely to be relatively minor compared to the oral pathway, and omission of this pathway is not likely to lead to a substantial underestimate of exposure or risk.

4.0   REFERENCES

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APPENDIX D
IEUBK MODEL INPUTS AND RESULTS

APPENDIX D

IEUBK MODEL INPUT PARAMETERS

Dietary Lead Intake: Values used for this site are equal to 70% of the EPA default values as follows. Rationale for the use of these values was presented in the Draft Baseline Human Health Risk Assessment for this site (EPA, 1999)

Age (years)	70% Dietary Intake (ug/day)
0-1	3.87
1-2	4.05
2-3	4.54
3-4	4.37
4-5	4.21
5-6	4.44
6-7	4.9

Geometric Standard Deviation (GSD): Values of both 1.4 and 1.6 were used at this site. This was done to encompass the range of GSDs for blood lead values seen at similar sites.

Water Lead Concentrations: For this analysis, lead concentrations in water at each property were assigned a value of 2.8 ug/L, based on the average measured value of lead in tap water.

Bioavailability: A value of 0.70 was adopted for the relative bioavailability of lead in soil and dust at this site. A more detailed discussion of this value can be found Section 5 of the Risk Assessment. This value corresponds to an absolute bioavailability of 0.35 as required for use in the IEUBK model.

Age Range: Geometric mean blood lead values were calculated for children aged 0 – 84 months.

SOIL-DUST RELATIONSHIP

$$Dust = 458 + 0.15*Soil$$

In order to reflect this relationship in calculating a PRG, the value of 0.15 was used as the contribution factor for soil to dust. The following values were input into "other" sources in order to account for baseline concentrations of lead in dust:

Age (years)	Other Intake (ug/day)
0-1	21.41
1-2	34
2-3	34
3-4	34
4-5	25.19
5-6	22.67
6-7	21.41

These values were obtained by multiplying the IEUBK default soil/dust intake parameters by 458 ug/g and 0.55 (the fraction of total soil plus dust intake that is dust).

APPENDIX E
ISE MODEL INPUTS

APPLICATION OF THE ISE MODEL AT THE EUREKA MILLS SITE

1.0   Introduction

Recently, a variation to the IEUBK model has been under development by USEPA Region 8. This model, referred to as the Integrated Stochastic Exposure (ISE) Model for Lead is similar to the IEUBK model, except that it uses probability density functions (PDFs) rather than point estimates as inputs for most concentration and exposure parameters. These distributions are combined using Monte Carlo simulation techniques to yield a predicted distribution of absorbed lead doses (ug/day) for different members of the exposed population. These doses are then used as input to the biokinetic portion of the IEUBK model in order to generate the predicted distribution of blood lead values in the population. Thus, the variability between children is evaluated in the ISE model based on the variability in environmental and exposure parameters, rather than by application of an assumed or estimated GSD value as in the IEUBK model. A more complete description of the model and of the input parameters can be found in Goodrum et al. (1996). Because this model has not yet undergone peer review or validation, it is considered to be only an investigative tool.

This model was used at the Eureka Mills Site in order to assess risks to children from exposure to lead in site media. This Appendix details the methods and input parameters used in this analysis. A brief discussion of the results is provided in the main text of the risk assessment in *Section 5.6.3 – Uncertainty in Modeling Approach*.

1.1   Model Inputs

All of the inputs used in the ISE model are based on the same data as were used in the IEUBK model analysis, except that distributions rather than point estimates were used for twelve model variables. These parameters are: soil/dust intake rate, fraction ingested as soil, environmental (dust, water, air) concentrations, dietary intake, absorption (soil, dust, water, and dietary), and air ventilation rate. These variables were selected for modeling as distributions because sensitivity analysis reveals that the output of the ISE model is especially sensitive to several of these terms (Griffin et al. 1999b). The basis for each of the distributions is summarized below.

Concentration of Lead in Soil

The ISE model was run using several different nominal soil concentrations ranging from 0 to 16,000 mg/kg. Observed site soil lead concentrations are within this selected range.

<u>Intake Rate</u>

Variability in the soil and dust ingestion rate (IR_{sd}) is described by a cumulative distribution derived from the Amherst, MA soil ingestion study (Stanek and Calbrese, 1995) as used by Griffin et al. (1999b) for the Murray Lead Smelter site. Since the IEUBK model uses a weighting factor for IR_{sd} based on the age of the child (e.g., some ages ingest more than others), this same weighting factor was used in this model. Values used in the model are shown in the following table.

Parameter	Description (units)	PDF	Parameters
IR_{sd}	Soil/dust ingestion rate (mg/day)	Cumulative	{0, 10, 45, 88, 186, 208, 225, 7000} {0, 0.25, 0.50, 0.75, 0.90, 0.95, 0.99, 1.0}

<u>Fraction Ingested as Soil</u>

The IEUBK model assumes that of the total ingestion of soil/dust, 45% is from outdoor soils and 55% is from indoor dust. For the ISE model, a triangular PDF was developed to describe the variability (reflecting seasonal and age-specific variability in childhood activity patterns) based on the default central tendency estimates in the IEUBK model (USEPA, 1994) and studies summarized by Pope (1985). The default min, mode and max values typically used in the model are 0.30, 0.45, 0.60, respectively. However, in order to introduce more variability into the model, the min and max values were adjusted, based on professional judgment as shown in the following table.

Parameter	Description (units)	PDF	Parameters
F_{soil}	Weighting factor, soil (unitless)	Triangular	{min, mode, max} {0.1, 0.45, 0.80}

<u>Concentration of Lead in Dust (mg/kg)</u>

The concentration of lead in dust was modeled as a lognormal distribution using the calculated mean (728 mg/kg) and standard deviation (428 mg/kg) of the dust data collected at the site.

For this model, this approach was preferred over calculating a point estimate of the dust concentration at each soil lead concentration based on the soil-dust relationship described in Section 2.2. As discussed in Section 2.2, lead concentrations in dust are not strongly correlated with soil lead concentrations. Thus, it is more appropriate to model this variable as an independent variable, than as a dependant variable calculated from the concentration of lead in soil.

Concentration of Lead in Water (ug/L)

The concentration of water was modeled using a lognormal distribution. This distribution was selected as most environmental data sets are right skewed and bounded by zero. The estimated mean and standard deviation of this distribution (2.8 ug/L $\pm$ 2.1 ug/dL) were estimated based upon the calculated mean and standard deviation of the site-specific tap water data.

Concentration of Lead in Air

A lognormal distribution was used to model air concentration. As for water, this distribution was selected as most environmental data sets are right skewed and bounded by zero. Because no measured air data were available at this site, the ISE model default value of 0.1 ug Pb/m^3 air was selected to use as the mean of this distribution and the standard deviation (0.05 ug Pb/m^3) was selected based on professional judgment.

Age Specific Intake Rate of Water/Ventilation Rate of Air

In the absence of information indicating otherwise, the age dependent intake rate of water and ventilation rate for air were modeled as lognormal distributions. The default values for these parameters in the IEUBK model were used as the means of the distribution, and the standard deviations were selected based on professional judgment. These values are listed in Attachment A to this Appendix.

Absorption Fraction for Lead in Soil and Dust

The absorption fraction is a measure of the amount of metal absorbed from the gastrointestinal tract into the body. This information is especially important for environmental media such as soil or mine wastes, because metals in these media may exist, at least in part, in a variety of poorly water soluble minerals, and may also exist inside particles of inert matrix such as rock or slag. These chemical and physical properties may tend to influence (usually decrease) the absorption (bioavailability) of the metals when ingested.

As discussed in Section 5.3.1, a relative bioavailability (RBA) value of 0.70 was selected for the absorption fraction for lead in soil at this site. Selection of this value was based on a comparison of site soils with test materials previously tested *in vivo* and results from *in vitro* bioaccessability testing.

The absorption fraction was modeled as a lognormal distribution using the absolute bioavailability (ABA) (0.35) as the mean of the distribution. The standard deviation of the distribution (10.5) was calculated by multiplying the ABA (0.35) by a conservative estimate

of the coefficient of variation (0.3) of absorption in children. In animal studies the coefficient of variation was generally observed to be around 0.2. To be conservative, as children are different than animals, a coefficient of variation of 0.3 was selected.

This distribution was also truncated to have a minimum value of at least 10% and a maximum value of 100%. These values were selected based on professional judgment as the bioavailability of lead in site soils cannot exceed 100% and is not expected to be less than 10%.

Other model input parameters were characterized by point estimate values rather than distributions. These include the following:

Exposure Frequency/Averaging Time

Exposure Frequency and Averaging Time variables were evaluated using a point estimate of 365 days per year. These values assume exposure to lead occurs every day. The model captures the variation in an individual child's daily exposure by the other input variable distributions.

Other Point Estimate Values

Other values that were entered as point estimates were the indoor concentration of air, age dependant time spent outdoors, lung absorption, and other (non-soil/dust). These values were left as parameters provided in the ISE model (SRC 1999).

A printout of inputs used in the ISE Model is provided as Attachment A to this Appendix.

1.2 Results –ISE Model Output

The results of the lead exposure assessment using the ISE model at various nominal concentrations are shown in the following table:

Lead Conc. mg/kg	P10 (%)
0	0
200	0.02
400	0.06
600	0.18
800	0.37
1,000	1.19
1,200	2.42
1,400	4.65
1,600	8.45
1,800	11.97
2,000	18.04
4,000	88.71
6,000	99.96
7,000	100
10,000	100
16,000	100

As shown, the P10 values predicted at this site increase as a function of increasing soil concentrations. The P10 value begins to exceed EPA's default value of 5% at soil lead concentrations greater than 1,400 mg/kg. At soil lead concentrations exceeding 6,000 mg/kg, the ISE model predicts that 100% of the estimated P10 values will exceed 5%.

These data were fit to the following equation describing the relationship between soil concentration and P10 (Figure D-1):

$$P10 = -.596 + 100.6(1 - \exp(-((C_{soil} + 3908 * \ln(2)^{1/4.31} - 2937.15)/3908)^{4.31})) \quad (R^2 = 0.99983)$$

This equation was then used to solve for the P10 at each of the 505 individual properties sampled within Eureka. The results for all 505 properties, grouped by area, are summarized in the table below:

Area	# of Properties	Average P10 (%)	P10 Value				Total with P10 >5%
			<5%	5-10%	10-20%	>20%	
1	218	28%	79	24	28	87	139 (64%)
2	93	12%	60	9	10	14	33 (35%)
3	6	37%	3	0	0	3	3 (50%)
4	116	43%	29	8	12	67	87 (75%)
5	61	35%	16	11	5	29	45 (74%)
6	11	30%	2	3	2	4	9 (82%)
All	505	30%	189	55	57	204	316 (63%)

The USEPA has set as a guideline for assessing risk from lead no more than a 5% probability of exceeding a blood lead level of 10 ug/dL. Overall, the ISE model predicts that 63% of the 505 sampled properties in Eureka will exceed this guideline. The highest percentages of properties exceeding this guideline are in Areas 4, 5, and 6, which are located to the south of Main Street (the road transecting the town on a North/South basis) and are in closer proximity to the identified mine waste piles.

When considering whether or not to use the ISE model as a tool to supplement an IEUBK-based evaluation of childhood exposure and risk from lead, the chief advantage to the risk assessor is that the estimate of the fraction of the distribution above the health-based criterion is based on all available data on inter-individual variability in exposure, rather than on an assumption that exposure is characterized by a lognormal distribution with a known (and usually default) GSD. In addition, use of the ISE model removes any ambiguities that exist in the IEUBK model regarding the desired input statistics (mean, median, some other undefined estimate of central tendency), and ensures that the distribution of exposure estimates is mathematically supportable. Until it is determined which approach yields the most reliable results, using the ISE model along with the IEUBK model will help ensure that risk managers and the public understand that predictions of both mathematical models are uncertain and imprecise, and that different approaches can yield different results.

ATTACHMENT A
ISE MODEL INPUTS

AT/EF:
=====

Exposure Frequency	Point	365.00	days/yr
Averaging Time	Point	365.00	days/yr

SOIL:
====

C_soil (soil Pb conc)   Point   600   ug Pb/g

IRsd (soil+dust IR)   PDF-Cumulative -------------- mg/day

   Number: 8 Min: 0 Max: 7000

   Values: {0,10,45,88,186,208,225,7000}

   Percen: {0,0.25,0.5,0.75,0.9,0.95,0.99,1}

Age: 0-1 IR scale factor	Point	0.6296
Age: 1-2 IR scale factor	Point	1
Age: 2-3 IR scale factor	Point	1
Age: 3-4 IR scale factor	Point	1
Age: 4-5 IR scale factor	Point	0.7407
Age: 5-6 IR scale factor	Point	0.6666
Age: 6-7 IR scale factor	Point	0.6296
Fs (frac ingest as soil)	PDF-Triangular	(0.1,0.45,0.8)

DUST:
====

C_dust (dust Pb conc)   PDF-Log Normal (728, 428)   ug Pb/g soil

WATER:
=====

C_water (water Pb Conc)	PDF-Log Normal	(2.8, 2.1)	ug Pb/L
Age: 0-1 IR Water	PDF-Log Normal	(0.2, 0.2)	L/day
Age: 1-2 IR Water	PDF-Log Normal	(0.5, 0.4)	L/day
Age: 2-3 IR Water	PDF-Log Normal	(0.52, 0.4)	L/day
Age: 3-4 IR Water	PDF-Log Normal	(0.53, 0.4)	L/day
Age: 4-5 IR Water	PDF-Log Normal	(0.55, 0.4)	L/day
Age: 5-6 IR Water	PDF-Log Normal	(0.58, 0.4)	L/day
Age: 6-7 IR Water	PDF-Log Normal	(0.59, 0.4)	L/day

DIET:
====

Age: 0-1 Diet Intake	PDF-Log Normal	(3.87, 2)	ug Pb/day
Age: 1-2 Diet Intake	PDF-Log Normal	(4.05, 2)	ug Pb/day
Age: 2-3 Diet Intake	PDF-Log Normal	(4.54, 2)	ug Pb/day
Age: 3-4 Diet Intake	PDF-Log Normal	(4.37, 2)	ug Pb/day
Age: 4-5 Diet Intake	PDF-Log Normal	(4.21, 2)	ug Pb/day
Age: 5-6 Diet Intake	PDF-Log Normal	(4.44, 2)	ug Pb/day
Age: 6-7 Diet Intake	PDF-Log Normal	(4.9, 2)	ug Pb/day

OTHER:
=====

Age: 0-1 Other Intake	Point	0	ug Pb/day
Age: 1-2 Other Intake	Point	0	ug Pb/day
Age: 2-3 Other Intake	Point	0	ug Pb/day
Age: 3-4 Other Intake	Point	0	ug Pb/day
Age: 4-5 Other Intake	Point	0	ug Pb/day
Age: 5-6 Other Intake	Point	0	ug Pb/day
Age: 6-7 Other Intake	Point	0	ug Pb/day

ABSORPTION:
==========

Soil: % accessible	PDF-Log Normal	(40,12,100,10)	percent
Dust: % accessible	PDF-Log Normal	(40,12,100,10)	percent
Water: % accessible	PDF-Log Normal	(50, 20)	percent
Diet: % accessible	PDF-Log Normal	(50, 20)	percent
Other: % accessible	Point	30	percent
Passive Fraction	Point	0.2	
Half Saturation Level	Point	100	ug/day

AIR:
===

Air Pb Conc Outdoors	PDF-Log Normal	(0.1, 0.05)	ug Pb/m3 air
Age: 0-1 Ventilation Rate	PDF-Log Normal	(2, 1.2)	m3 air/day
Age: 1-2 Ventilation Rate	PDF-Log Normal	(3, 1.4)	m3 air/day
Age: 2-3 Ventilation Rate	PDF-Log Normal	(5, 2.4)	m3 air/day
Age: 3-4 Ventilation Rate	PDF-Log Normal	(5, 2.4)	m3 air/day
Age: 4-5 Ventilation Rate	PDF-Log Normal	(5, 2.4)	m3 air/day
Age: 5-6 Ventilation Rate	PDF-Log Normal	(7, 3.4)	m3 air/day
Age: 6-7 Ventilation Rate	PDF-Log Normal	(7, 3.4)	m3 air/day
Indoor Conc (% of Outdoor)	Point	30	percent
Age: 0-1 Time Outdoors	Point	1	hr/day
Age: 1-2 Time Outdoors	Point	2	hr/day
Age: 2-3 Time Outdoors	Point	3	hr/day
Age: 3-4 Time Outdoors	Point	4	hr/day
Age: 4-5 Time Outdoors	Point	4	hr/day

Age: 5-6 Time Outdoors   Point   4   hr/day
Age: 6-7 Time Outdoors   Point   4   hr/day
Lung Absorption Age 0-1   Point   32   percent
Lung Absorption Age 1-2   Point   32   percent
Lung Absorption Age 2-3   Point   32   percent
Lung Absorption Age 3-4   Point   32   percent
Lung Absorption Age 4-5   Point   32   percent
Lung Absorption Age 5-6   Point   32   percent
Lung Absorption Age 6-7   Point   32   percent

2-D Selected Variables:
========================
    None

MISCELLANEOUS:
==============
 Post-Remediation Values:
   Pre-Remediation Conc (ppm): 1500
   Backfill Soil Conc (ppm) : 50
    PDF: Point